FOURTEENTH ANNUAL REPORT

OF THE

NEW JERSEY STATE

Agricultural Experiment Station

AND THE

SIXTH ANNUAL REPORT

OF THE

New Jersey Agricultural College Experiment Station

FOR THE YEAR

1893.

TRENTON, N. J.:
THE JOHN L. MURPHY PUBLISHING COMPANY, PRINTERS.
1894.

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Fourteenth Annual Report

OF THE

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PART I.

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To His Excellency George T. Werts, Governor of the State of New Jersey:

SIR—I have the honor to submit herewith the fourteenth annual report of the New Jersey State Agricultural Experiment Station, as required by the law establishing the Station, which was approved March 10th, 1880, and which is chapter CVI. of the laws of that year.

ABRAHAM W. DURYEE,
President.

NEW BRUNSWICK, N. J., December 31st, 1893.

BOARD OF MANAGERS.

HIS EXCELLENCY GEORGE T. WERTS, Trenton,
Governor of the State of New Jersey.

AUSTIN SCOTT, PH.D., LL.D., New Brunswick,
President of the State Agricultural College.

EDWARD B. VOORHEES, A.M.,
Professor of Agriculture of State Agricultural College.

FIRST CONGRESSIONAL DISTRICT.

	Residences.	*Terms Expire.*
*THOMAS H. DUDLEY,	Camden,	....
HENRY FREDERICK,	Camden,	1895.
DANIEL W. HORNER,	Merchantville,	1895.

SECOND CONGRESSIONAL DISTRICT.

JOSHUA FORSYTH,	Pemberton,	1895.
RALPH EGE,	Hopewell,	1895.

THIRD CONGRESSIONAL DISTRICT.

DAVID D. DENISE,	Freehold,	1895.
JAMES NEILSON,	New Brunswick,	1895.

FOURTH CONGRESSIONAL DISTRICT.

WILLIAM H. GREEN,	Succasunna,	1895.
BENJAMIN F. TINE,	Stanton,	1895.

FIFTH CONGRESSIONAL DISTRICT.

ABRAHAM W. DURYEE,	New Durham,	1895.
SAMUEL R. DEMAREST, JR.,	Hackensack,	1895.

SIXTH CONGRESSIONAL DISTRICT.

JESSE B. ROGERS,	Newark,	1895.
CHARLES L. JONES,	Newark,	1895.

SEVENTH CONGRESSIONAL DISTRICT.

JAMES STEVENS,	Jersey City,	1895.
JAMES MCCARTHY,	Jersey City,	1895.

EIGHTH CONGRESSIONAL DISTRICT.

WILLIAM R. WARD,	Newark,	1895.
GEORGE W. DOTY,	Union,	1895.

* Died April 15th, 1893.

ORGANIZATION

OF THE

NEW JERSEY (STATE) AGRICULTURAL EXPERIMENT STATION.

OFFICERS OF THE BOARD.

ABRAHAM W. DURYEE, A.M., New Durham..................................President.
WILLIAM R. WARD, Esq., Newark..Secretary.
IRVING S. UPSON, A.M., New Brunswick.....................................Treasurer.

OFFICERS OF THE STATION.

EDWARD B. VOORHEES, A.M..Director.
LOUIS A. VOORHEES, A.M...Chemist.
JOHN P STREET, M.S..Chemist.
IRVING S. UPSON, A.M...Chief Clerk.
MARY WHITAKER...Clerk to the Director.

RICHARD TITUS.....................................Janitor and Laboratory Attendant.

TREASURER'S REPORT.

Irving S. Upson, in account with the New Jersey Agricultural Experiment Station, January 1st, 1893, to January 1st, 1894:

RECEIPTS.

From State Treasurer	$10,252 83

PAYMENTS.

Salaries and pay of chemists and assistants	$6,514 85
Expenses of the Board of Managers	70 21
Stationery, including envelopes for Bulletins and Reports	386 48
Printing	1,492 61
Postage	55 90
Telephone and telegraph service	86 00
Furniture	132 50
Gas and water	127 37
Laboratory expenses	523 10
Field and feeding experiments	348 40
Freight, express and cartage bills	116 06
Expenses collecting samples of fertilizers	338 17
Traveling expenses	348 20
General fittings	258 07
Insurance	42 25
Annual dues, American Association Agricultural Colleges and Experiment Stations	10 00
	$10,850 17

Respectfully submitted,

IRVING S. UPSON,
Treasurer.

The Auditing Committee of the Experiment Station have examined the accounts of the Treasurer of said Station and find them correct.

SAMUEL R. DEMAREST, Jr.,
JESSE B. ROGERS,
Auditing Committee.

REPORT OF THE DIRECTOR.

REPORT OF THE DIRECTOR.

EDWARD B. VOORHEES.

In the work of the Station the past year no effort has been made to cover the whole field of agricultural investigation; on the contrary, extra efforts have been made to broaden and strengthen the limited lines of work followed in the past, viz.:

1. A study of the composition and value of commercial fertilizers.
2. The conducting of field experiments with fertilizers.
3. A study of the composition and value of fodder plants.
4. The analyses of fodders and feeds, and their study in relation to the dairy industry and to stock-raising.

The Station is well equipped for these lines of work, both in men and apparatus, and the results secured are believed by the Board of Managers and officers to be both directly and indirectly of the greatest usefulness to the farmers of the whole State.

ANALYSES OF COMMERCIAL FERTILIZERS.

Owing to existing conditions in this State, in reference to crops and markets, the farmers are largely prosperous as they approach in their practice the "intensive system," or the growing of crops which are limited in yield only by the prevailing conditions of climate and season.

This system requires a very liberal use of manures, in order that soil conditions may be equal to, or meet the requirements of such maximum production. The natural consequence of this tendency to intensive culture is, therefore, an increased use of artificial preparations, or fertilizers; the cost of these materials amounting now to more than $1,500,000 annually.

The uncertainty in regard to the quality of the various brands, due both to the variety of the materials from which they may be derived, and to the opportunity afforded for carelessness in their preparation, makes their published analyses and valuations, when conducted by proper authorities, extremely valuable to consumers; first, in indirectly forcing manufacturers to maintain a higher standard not only of guaranteed, but of actual quality, and second, in furnishing direct and accurate information as to the best and cheapest brands.

ANALYSES OF FERTILIZING MATERIALS.

This work is regarded as of more direct value to intelligent consumers than the former, in that it calls attention to the composition and value of the various forms and kinds of fertilizing materials, and the sources of supply of the manufacturers themselves. Many of these materials are in a condition to use directly upon the land, and further, they are of such a character as to make it within the power of the farmer to prepare mixtures quite as good as the manufacturers themselves, so far as condition and evenness of mixing go, with the additional advantage that they may be especially adapted for his purposes. The Station has shown that knowledge thus given, as to the kinds and forms of fertilizing materials, their chemical composition, sources of supply, and method of mixing, or, in other words, what fertilizers are, has resulted not only in a greatly decreased cost per pound of the actual fertilizing constituents to consumers, but in a considerable saving in labor in handling the less bulky products; further than that, it is also plainly evident from statistics gathered in certain sections of the State, that the lower cost induces a larger proportionate use, and that the larger use results in an increased profit.

Many farmers' clubs and granges are now buying their fertilizers in this way, and several transactions by such organizations this year, which involved the purchase of 700 tons of materials, were carefully studied by the Station in order to show the actual gains that were made. The 700 tons cost $20,790, or on an average at the rate of 14.9 cents per pound for nitrogen, 5.7 cents per pound for available phosphoric acid and 4 cents per pound for potash. The average cost per pound of these fertilizer elements, bought in mixed goods from dealers, is this year 24.8 cents for nitrogen, 9.4 cents for available phosphoric acid and 6.7 cents for potash. The total cost of the amounts of con-

stituents contained in the 700 tons would, on this basis, have been $34,489, or a difference in favor of the former method of $13,699, on a transaction which represents less than one-thirtieth of the total annual consumption in the State. This study also showed that if the average manufactured fertilizer had contained as much plant-food as was contained in the mixtures made from the 700 tons of materials purchased, the total amount used in 1892 would have been contained in 23,172 tons, instead of 33,821 tons, or a difference of 10,649 tons. A comparison of the selling price and valuation of the mixed goods examined this year shows further that the cost to the farmer for mixing, bagging and selling averaged $9.70 per ton, or a total for the 10,649 tons of $93,295. That is, the labor connected with the handling and selling of 10,000 tons of absolutely worthless materials amounted to nearly $100,000. Savings like these, both actual and prospective, which are the legitimate result of a knowledge of but two phases of the fertilizer question, viz., method of buying and concentration of product, but illustrate the financial importance to the farmers of the State of this line of investigation and the advisability of a continuance of it until all farmers are brought to understand the importance of it to them. This may be illustrated by the fact that now one farmer, who represents a class becoming larger year by year, is enabled by careful study of conditions to purchase available phosphoric acid for 4¼ cents per pound, while another, who represents a class growing smaller year by year, who does not study the relation of composition and selling prices, does pay as high as 14 5 cents per pound for the same constituent when contained in a standard brand. This line of work is also universally applicable. It applies to the general farmer, the gardener, the fruit-grower, the dairyman and stockman, just in proportion as he needs to increase his fertility.

Under the exercise of an analysis control, too, the manufacturers, as a rule, conform to the law. Thus, when farmers pay an unreasonable price for their fertilizers, as many of them do, it is because they do not take advantage of the information furnished them by the Station. There is, however, as already intimated, encouraging progress in this direction, owing to the Station's persistent efforts in this line. In the prosecution of the work this year, the following analyses have been made and reported:

Complete Fertilizers	258	samples.
Fertilizing Materials	95	"
Ground and Dissolved Bone, and Miscellaneous Products	52	"
Total	405	"

Each complete fertilizer requires at least eight separate tests. These are conducted in duplicate, except where the test shows the absence of any one constituent, as in the case of nitrogen as ammonia or nitric acid. The determinations required in fertilizer supplies or miscellaneous products, range from one to six. The performance of this work, which is very laborious, besides requiring the highest skill in connection with the securing and preparation of samples, is now beyond the capacity of the Station during the season that should be devoted to this work; it was accomplished this year only through the self-denying and persistent efforts of the chemists employed.

FIELD EXPERIMENTS WITH FERTILIZERS.

The market or commercial value of a fertilizer bears no direct relation to its agricultural value. The use of a pound of potash, which may cost from four to ten cents per pound, may in one case result in an increase of crop worth ten cents, while in another its use may not result in any increased production. It is a legitimate field of investigation to determine by experiment or actual trial on different soils and crops, not only whether any element of fertility is useful, but its best use under the varied conditions of soil and crop. A prominent feature of the work of this Station has, therefore, been the conducting of field experiments, with the end in view of determining the most economical use of the different kinds and forms of manures, both natural and artificial. This work is not regarded as of the highest scientific character, because all conditions cannot be controlled, and because it is claimed that the results are only applicable for the specific field and plot upon which the experiment is conducted.

There seems to be, however, compensating errors, for, notwithstanding these restrictions upon the usefulness of field experiments from the scientific standpoint, the results secured by the Station have been of very great value—first, in indicating positively economical methods of manuring, and second, in educating farmers as to what actually constitutes a manure, and familiarizing them with the vari-

ous fertilizing materials and forms of manurial constituents, and the principles which govern their action in the soil.

In our progress toward a more intensive system of farming, one of the first questions to be determined is, whether yard manure may be supplanted in whole or in part by the artificial products. The great importance of this question is due to a number of facts. Farmers are familiar with the use of yard manure. They know that an increased yield will follow liberal applications, and that no bad effect is liable to follow heavy dressings, and that its effects are relatively permanent.

These reasons appeal strongly to those who are unacquainted with the principles that govern in the use of artificial products. Yet a study of the situation shows that the supply is relatively limited; that it acts slowly, and therefore, to secure maximum crops, particularly of early produce, large quantities must be applied, making it very expensive. Its bulky character also makes the handling of such large quantities extremely costly. The evidence derived from our field experiments is cumulative in showing that, so far as yield is concerned, chemical or artificial manures may supplant yard manure, not only in part but wholly, upon land already in good condition, and that in these cases the net profits from the use of the former are far greater than from the latter. This is particularly true of the following leading farm crops of the State, which require for their most profitable production the liberal use of plant-food, viz., white potatoes, sweet potatoes, tomatoes and fruit, including peaches and pears. These experimental results, derived from small areas, have been verified, too, by actual field trials, the results being so satisfactory that in several parts of the State entire communities have changed their method of manuring, and it is worthy of record that these communities include our most prosperous farmers, a result due in no small degree to the influence of field experiments.

These experiments are under the direct supervision of the Station. In planning and management an officer, as far as possible, superintends the measuring of the plots, the preparation and application of the fertilizers and manures and the harvesting and weighing of the crop. During the past season experiments have been carried out on ten farms, located in six counties, and including eight different crops, as follows:

White potatoes	Gloucester and Somerset counties.
Sweet potatoes	Gloucester and Cumberland counties.
Tomatoes	Gloucester county.
Asparagus	Monmouth county.
Strawberries	Middlesex county.
Peach trees	Somerset county.
Salt grass	Ocean county.

Frequently, too, samples of the produce from the different plots are subjected to chemical analysis, thus materially increasing the labor involved in these studies. Plans are now being matured looking toward a more scientific investigation of the question of plant nutrition by means of pot experiments, the object being to duplicate the field work in such a manner as to more completely control conditions of soil impossible in field work.

EXPERIMENTS WITH GREEN MANURES.

There are large areas of light lands in this State, within easy distance of excellent markets, which are now unproductive. Many of these soils possess a retentive subsoil, and are apparently capable of decided improvement. In addition, therefore, to the specific fertilizer tests, two experiments were begun this year, for the purpose of studying the improvement of these light, sandy soils, by means of cheap forms of the mineral constituents, potash and phosphoric acid, in connection with green manures. The green crop grown this year was cow pea. This plant made an excellent growth, thus furnishing a large amount of organic vegetable matter so important in this class of soils. The crops grown are to be accurately weighed and samples taken for analysis, in order to determine the gain of nitrogenous organic matter by means of the green manure. The amount of plant-food removed by the crops harvested is also to be determined, thus permitting an accurate record of loss and gain to be kept. This line of experiments, which also contemplates a study of rotation of crops, promises to be of great value, mainly, because of the wide application of the results, though considerable time must elapse before positive conclusions can be reached.

CROP TESTS.

The investigation of new varieties of plants, in reference to their adaptability to the soil and climate of the State, as well as their use-

fulness for our various conditions, has this year been confined mainly to a study of scarlet or crimson clover.

This work was begun in 1891, and the results secured were so favorable in indicating the wide usefulness of the plant, that in 1892, in addition to specific experiments by the Station, a large number of farmers were induced to grow small areas under directions sent by the Station, mainly to test its hardiness. Reports were received from 20 farmers, representing 10 counties. These reports were also uniformly favorable in indicating entire hardiness, not only, but in suggesting its great importance as an early fodder for dairy farms, and as a catch crop to be used either as pasture or as green manure. These reports in connection with the investigations of the Station, were incorporated in the Annual Report for 1892. This year, in addition to further experiments to test hardiness in the more northern counties of the State, systematic experiments were conducted to determine the yield and quality of the crop at different stages of growth as having reference both to its use as pasture and as a green fodder or hay, and to its importance and value as a green manure. These experiments were conducted upon three farms, and 21 samples representing tops, roots and stubble are in process of analysis at the present time.

The results so far secured are positive in showing that in yield and quality of produce it is superior to our common red clover, and that for a wide variety of purposes it is a most valuable addition to our farm crops, particularly as its growth need not interfere materially with regular and valuable farm rotations. An experiment is also in progress on the College farm, having for its object a study of rotations for the dairy, in which scarlet clover forms a prominent part, and its importance in the double capacity of fodder plant and as a factor in maintaining fertility will thus receive careful investigation.

ANALYSES OF FODDERS AND FEEDS.

This work grows in amount and value from year to year, and may be properly discussed under the following separate divisions: 1. The analyses made necessary by the investigation of new fodder plants. The results here are valuable—first, in adding directly to our stock of definite knowledge, and second, in showing the relation of such products to the economical feeding of stock. 2. Those in connection with feeding experiments. The results of these analyses are mainly

valuable in furnishing exact data for studying the nutritive effect of various kinds and proportions of food compounds in the rations for farm stock, though they also serve a useful purpose in furnishing increased data, from which to determine the average composition of the various products. 3. The analyses of commercial feeds. A frequent examination of market products is useful for the following reasons: 1. It shows the variations in composition liable to occur under ordinary conditions in feeds of the same class; 2. It permits a detection of possible adulteration; 3. It indicates changes in composition of the different refuse mill-products, due to improved or changed methods of manufacture; 4. It directs attention to new products, consequent upon the establishment of new or economical development of older industries engaged in the manufacture of agricultural products. In all cases the analyses include the determination of the fertilizer constituents, thereby aiding in showing the relation of the feeding of various rations to fertility. This work has resulted in showing that the feeds offered for sale in this State are of uniformly good character and free from adulteration. The chief investigation now in progress is the study of the character and composition of the various gluten feeds, products resulting from the manufacture of starch and glucose from corn. These are excellent feeds, though owing to the various methods employed in their manufacture, the name "gluten feed" does not always indicate the character and composition of the product. Manufacturers are heartily co-operating in this investigation by furnishing useful data, and it is believed that the results secured will be of considerable scientific value as well as of direct practical usefulness to farmers in the State.

MARKET PRICES OF COMMERCIAL FEEDS.

Investigation in this line is also made more valuable by the annual collection of data in reference to the prices of commercial feeds. So far this work shows that market prices are not controlled to any extent by feeding value, and that those feeds which are particularly advantageous to the farmer in the use of his coarse farm products furnish the food compounds at the lowest cost, are least liable to fluctuation in price and are also the most valuable from the standpoint of fertility. These facts have a most important bearing in the use of farm produce. Because a farmer raises a feed, it does not follow that

it will pay him better to feed it than to sell it, but rather, by a judicious sale of carbonaceous farm produce, poor in the fertilizing elements, and an economical buying and proper using of nitrogenous feeds rich in fertilizing elements to feed animals at a profit, and from the resulting manure secured without cost to raise maximum grain crops without an extensive purchase of commercial fertilizers. These points have also been made the basis of investigations by means of feeding experiments, and these theoretical considerations have been verified by the results obtained.

FEEDING EXPERIMENTS WITH HORSES.

These experiments were begun in 1892, the primary object of which then was to study the effect and economy of a pound-for-pound substitution of dried brewers' grains for oats. The results of these experiments were so positive in showing savings, not only in quantity of food, but the advantages of a knowledge of the proper use of food compounds or actual nutrients, that the investigations were continued this year on lines that are quite as important in indicating more rational methods of feeding.

The experiment was conducted with the horses at the College farm. Four horses were included in the experiment—two on regular farm work, and two used in delivering milk, thus making the conditions conform closely to those of the majority of farmers of the State.

The main objects of the experiment this year were—first, to determine whether the amount of timothy hay ordinarily fed to horses was necessary, and second, whether rations that did not include oats could be satisfactorily fed, these two products at the average present prices being the most expensive feeds at the farmer's command. The results of these experiments, which are recorded in the body of the report, are positive in showing that for farm horses on average work, hay fed in the usual amounts is not essential but wasteful, and that specific proportions of food compounds rather than kind of material, as oats, corn, etc., should be the guide in the preparation of rations. The results indicate, further, a saving of at least five cents per horse per day in the cost of a ration. It is gratifying, also, to record that this study is already having a practical influence. One farmer has re-

ported that the suggestions of the Station in this matter had resulted in saving him $150 per year in the feeding of eight horses.

It has also incited numerous inquiries from parties in cities, who keep a large number of horses for heavy work.

FEEDING EXPERIMENTS WITH DAIRY COWS.

As early as 1884 experiments were conducted at this Station to determine the relative value of wet and dried brewers' grains. The result of this study indicated that practically little difference in milk flow would follow the substitution of dried grains for moist, on the same basis of food compounds. The necessity of a further inquiry into this question seemed justified by the fact that improved methods of drying the grains have resulted in great reductions in their cost. A pound of dried grains is equivalent in food to from 3½ to 4 pounds of the wet product. The cost of the wet grains to the consumer ranges from $6 to $8.50 per ton, while that of the dried ranges from $17 to $19, thus making the cost of the food in the wet grains from 25 to 50 per cent. greater than in the dried, while in the wet grains the expense of labor and liability to loss are much greater. Farmers are loth to change methods of feeding in any case, and the excellent results secured by them from the use of wet grains causes them to question very closely the advisability of a change. It is believed that this study will materially aid in determining the proper ratio of wet to dried product from the practical feeder's standpoint. The results will probably be ready for incorporation in this report.

The question of rational feeding is one of great importance to our farmers, and, in addition to the work already mentioned, a bulletin was issued in November entitled "Hay Substitutes." The situation of our farmers this year in reference to home-grown produce, particularly corn and hay, was so serious that it seemed advisable to state as clearly as possible the underlying principles of feeding, and to suggest economical uses of coarse products by the rational buying of feeds. This bulletin was well received, and, judging from the grateful letters of feeders, is proving of great practical usefulness to the farmers at this time.

MISCELLANEOUS CHEMICAL ANALYSES.

During the winter season many chemical analyses are made that cannot be classed as belonging to any specific investigation. Their value is local rather than general, though in all cases the results more than justify the labor expended. These analyses include samples of muck, marl, animal manures, sugar beets, milk, etc. Usually the analyses are made in connection with some specific inquiry in reference to the treatment of land, or the value of some waste product. These inquiries, when answered in detail in this way, are often of value to others, and therefore they prove of general use when they appear in our reports.

STUDY OF CHEMICAL METHODS.

This feature of the Station's work has been of the greatest usefulness. The work has reference both to the development of new and improved apparatus and to the adoption and use of chemical methods that enable work to be accomplished at a greater speed, while at the same time preserving its scientific accuracy. At least a month of the time of the chemists is given to this work each year, part of which is carried out in connection with the Association of Official Agricultural Chemists, in the work of which our Station has always taken a prominent and active part. This association has for its object not only the study of methods of agricultural chemical analyses, but the development of uniformity in the methods employed by the various chemists. The value of work of this kind is shown when the present conditions are compared with those of former years. The State appropriations to the Station have not been increased since 1884, and the number of chemists employed now is the same as at that time, our chemical work on products, other than fertilizers, is quite as great and the investigations in other lines equal, in point of labor involved, to those then conducted; yet, the number of analyses and the accompanying tabulations and clerical work have, however, increased from 75 complete fertilizers in 1884 to 258 in 1893, while the number of analyses of incomplete has increased in the same time from 110 to 146. It has been possible to accomplish this increased work largely through the improvement of methods. There is a limit, however, to the development in this line, and if the work continues to increase other means must be provided for meeting it.

PUBLICATIONS.

The publications of the Station since the annual report of last year are as follows:

Bulletin No. 92.—Feeding Experiments with Horses. Dried Brewers' Grains *vs.* Oats.

Bulletin No. 93.—Analyses and Study of Home-mixed Fertilizers and Fertilizing Materials.

Bulletin No. 96.—Corn Stalks and Straw as Hay Substitutes. A Bulletin of Information.

Bulletin No. 97.—Analyses and Valuations of Complete Fertilizers, Ground Bone and Miscellaneous Samples.

These bulletine have aggregated 107 pages, and each bulletin has been distributed to over 15,000 farmers in the State. The cost for printing and envelopes, not including office work, is about 2½ cents per copy. This seems small, yet this cost makes a serious drain upon the resources of the Station, amounting to something over $1,500. The State prints and furnishes to the Station about 5,000 copies of the annual report. These for 1892 have also been largely distributed, though, owing to the fact that the State does not furnish a sufficient number for our entire mailing list, it becomes a difficult as well as an expensive matter for the Station to determine to whom they shall be sent. The matter of publication is also worthy of serious consideration from another standpoint. The bulletins report only about one-half of all the work done, and frequently the person receiving them does not find that which is of the most interest to himself, and does not know that what he is particularly interested in is in the annual report, a copy of which he does not receive. There should be either a larger edition of the annual report, or the bulletins should cover more nearly the whole work done. This latter cannot now be done with the resources at the Station's command, because of the cost of printing. The great demand for our bulletins is sufficient evidence of their appreciation, both by our own farmers and those of other States and countries. In many cases the editions are exhausted before the local demand has been supplied. The editions should not be reduced; they should more completely cover the work done.

CORRESPONDENCE.

All inquiries from residents of the State in reference to farm matters receive very careful consideration; these inquiries are very frequent at certain seasons of the year, when farmers have leisure to plan for the future. The labor involved in properly performing this work is considerable and constitutes a serious drain upon the time of the Director, the result of which, so far, does not appear as a part of the published records. It is hoped this year that the most important part of the inquiries and answers may be edited and prepared for publication in the annual report. In an attempt to classify this correspondence, eliminating all matter that was not of the nature of a specific inquiry from a farmer, it was found that over 50 per cent. of the letters were in reference to the composition and use of manures and fertilizers, 25 per cent. in reference to fodders and feeds and the preparation of rations, and the remainder about equally divided between soils and crops, and matters of a miscellaneous nature. There is not much doubt but that the line of investigations that we are known to pursue has its influence in determining the line of inquiry, yet I am satisfied, both from the nature of the letters and from my knowledge of the farmers and their conditions, that the primary and all-important question with the majority of farmers is, how to buy and use manures. They want to know how to proceed to raise maximum crops most cheaply. Many letters are also received from other States, and while courteous replies are always granted, it is aimed as far as possible, to satisfy their demands by sending bulletins bearing upon the topics of inquiry. The regular employment now of a stenographer and typewriter, and the introduction of improved office appliances, materially aid in the discharge of this important part of the Station's work.

ADDRESSES AND LECTURES.

This work has increased very largely in the past few years both in amount and usefulness. The requests from County Boards of Agriculture, Farmers' Institutes, and various farmers' organizations are at present so regular from year to year that these lectures now admit of a detailed and consecutive presentation of the scientific principles which govern in farm practice. Besides this educational feature,

opportunities are furnished for bringing the work of the Station prominently before the farmer, and also to call to his attention matters of importance that do not legitimately belong to regular Station work. This work also renders it possible for the Station to obtain a wide aquaintance, both of the farmers and of their conditions, which is of direct usefulness in guiding the Station in planning investigations of practical importance; besides, this direct contact with the Station's officers creates among them a deeper confidence in the work performed.

RECOMMENDATIONS.

A careful review of the work of the Station shows plainly that with the present appropriation new work cannot be attempted without the abandonment of lines that now seem to be of great value to all of our farmers. In fact, any increase in the work already undertaken must be consequent upon increased funds; yet the importance of investigations, particularly in the horticultural branch of our farming, is worthy of careful consideration by the Board of Managers.

REPORT OF THE CHEMISTS.

REPORT OF THE CHEMISTS.

I. Fertilizers:

I. Fertilizer Statistics:

1. The quantity and value of the fertilizers used in this State during the year 1893.
2. Comparison of this year's trade with that of preceding years.

II. The Commercial Relations of Fertilizers:

1. Their market prices.
2. Incomplete fertilizers; their economic purchase and rational use.
3. Home mixtures; formulas, composition and cost.
4. Complete fertilizers, bones and miscellaneous products; their guaranteed chemical composition and relative commercial value.

III. The Agricultural Relations of Fertilizers:

1. To test the effects of nitrate of soda, when used alone and in connection with the mineral elements, phosphoric acid and potash, upon the yield and maturity of tomatoes.
2. To test the effect of potash in the form of muriate and sulphate, and of barnyard manure alone and in combination with chemical manures, upon the yield of white potatoes.
3. To test the effect of nitrogen in the form of nitrate of soda and dried blood, and of barnyard manure alone and in combination with chemical manures, upon the yield of sweet potatoes.
4. To test the effect of the best forms of fertilizing constituents upon the yield of salt grass, when used singly and in combination.

5. To test the effect of the essential fertilizing elements, either alone or in combination, and the effect of what may be considered a sufficient excess of the plant-food elements upon the health and productiveness of peach trees.
6. To test the effect of a top-dressing of nitrate of soda upon strawberries.

II. Miscellaneous Experiments:

I. To determine the value of chemical manures alone in the growth of asparagus.
II. To study methods of improving poor lands by means of green manures.
III. To study crop rotations for dairy farms.

III. Crop Tests:

I. Scarlet Clover:

1. To test the adaptability of scarlet clover to the soil and climate of this State, and its value as a forage plant, as hay and as a green manure.

II. Sugar Beets.

IV. Fodders and Feeds:

I. Analyses.
II. Market Prices of Commercial Feeds.
III. How Shall Farmers Best Dispose of Their Produce?
IV. Average Composition of Fodders and Feeds.

V. Feeding Experiments with Farm Horses.

FERTILIZERS.

I.

FERTILIZER STATISTICS.

1. The quantity and value of the fertilizers used in New Jersey during the year 1893.

2. Comparison of this year's trade with that of preceding years.

These statistics were taken by manufacturers from their books in answer to requests made by this Station. The reports were in each case returned on printed forms, of which the following is a copy:

SALES OF COMMERCIAL FERTILIZERS.

The following is a correct statement of the number of tons of the several classes of Commercial Fertilizers sold in New Jersey by ——— ——— during the year ending November 1st, 1893:

Number of tons of Complete Manure...... ....
" " Ammoniated Superphosphate without Potash, including Dissolved Bone, etc..
" " Ground Bone................. ....
" " Kainit...
" " Muriate of Potash ....
" " Nitrogenous matter...
(*a*) Ammonium Sulphate..
(*b*) Sodium Nitrate ....
(*c*) Blood, Ammonite, etc..
Number of tons of Plain Superphosphates, including both Dissolved Bone Black and S. C. Acid Phosphate..................................

The above circular was mailed to 112 firms, 80 of which, including those that have the largest sales in this State, forwarded itemized statements. These indicate a total consumption for this year in New Jersey of 51,758 tons, divided as follows:

1.

THE QUANTITY AND VALUE OF THE FERTILIZERS USED IN NEW JERSEY DURING THE YEAR 1893.

	Tons reported as sold in New Jersey.	Average retail price per ton.	Total value.
Complete Manures	37,927	$34.11	$1,293,690
Dissolved Bone, etc	2,222	31.33	69,615
Ground Bone	3,021	32.50	98,183
Kainit	1,056	11.43	12,070
Muriate of Potash	695	41.22	28,648
Ammonite, Dried Blood, Dried Fish, etc	*3,317	35.51	69,427
Ammonium Sulphate	113	67.28	7,603
Sodium Nitrate	221	49.27	10,889
Bone-Black Superphosphate	1,208	18.98	22,928
S. C. Rock Superphosphate	1,978	14.44	28,562
Total number of tons and value	51,758	....	$1,641,615

*Includes 1,696 tons of hair manure, at $7 per ton.

Although it is admitted that these statistics are incomplete, as they represent only about four-fifths of the manufacturers who sell fertilizers in this State, yet the number of manufacturers who did reply to our inquiries this year is greater than ever before. These 80 firms represent the greater part of the fertilizers sold in the State; those manufacturers who have not replied, as a rule, being those whose total output averages less than 50 tons per annum.

As stated in previous annual reports, this statistical work is carried out without legal authority, the data being secured only through the courtesy of those manufacturers who, year after year, at their own expense, compile their reports in answer to direct requests.

The Inspectors who represent this Station report the retail prices of every brand sampled by them. These reports furnish the data from which the above average retail price for complete manures was obtained. The average retail prices for kainit and all other products tabulated below it were secured from sales made directly by the manufacturers to farmers, consequently they do not include charges for freight, cartage, etc.

The complete manures represent 73 per cent. of the total number of tons sold last season, and nearly 79 per cent. ot the total value of all sales.

2.

COMPARISON OF THE YEAR'S TRADE WITH THAT OF PRECEDING YEARS.

The total sales of fertilizers reported this year are the largest in the history of the Station. The complete fertilizers, 37,927 tons, indicate an expenditure this year of about $1,300,000, or 79 per cent. of the total.

In raw materials an increase is noticed in all cases except bone and rock superphosphates and dried fish. The amount of ground bone reported as sold during the last year is fully 30 per cent. more than in 1892.

Tonnage of Fertilizers Used in New Jersey.

	1882.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.	1893.
Number of tons of Complete Manure	15,941	21,894	22,424	24,498	22,500	25,413	23,864	27,236	29,431	33,821	37,927
" " Ammoniated Superphosphate without Potash (Dissolved Bone, etc)	1,370	1,541	1,603	1,343	1,898	1,016	1,067	998	1,101	1,628	2,222
" " Ground Bone	2,509	3,172	2,237	2,338	2,465	2,036	1,498	1,679	2,735	2,308	3,021
" " Kainit	683	991	584	1,106	1,220	604	625	567	784	825	1,056
" " Muriate of Potash	144	291	331	255	314	449	491	393	560	552	695
" " Ammonite	719	783	250	*698	....	*1,703	†306	305	†128	†422	†418
" " Ammonium Sulphate	76	54	55	21	95	53	95	97	92	103	113
" " Sodium Nitrate	26	40	17	24	93	157	205	133	151	193	221
" " Blood	244	1,581	263	....	411	....	....	....	....	....	....
" " Fish	228	228	....	....	184	....	1,184	1,009	1,938	958	902
" " Hair	248	574	434	723	363	....	677	....	761	1,353	1,696
" " Poudrette	3,450	10,200	6,000	5,000	....	....	....	....	....	....	‡301
" " Superphosphates, 30 to 40 per cent	562	....	....	....	....	....	....	....	....	....	....
" " Superphosphates, 11 to 18 per cent	3,963	5,315	....	....	....	....	....	....	....	....	....
" " Bone-Black Superphosphate	....	....	2,488	594	370	457	572	4,925	2,388	2,048	1,208
" " S. C. Rock Superphosphate	....	....	1,124	2,078	1,303	1,745	1,662	2,174	3,345	3,443	1,978
Total	30,163	46,664	37,810	38,678	31,216	33,633	32,246	39,516	43,414	47,654	51,758

*The total number of tons, in 1886 and 1888, under Ammonite, includes both blood and fish, returns having been made, in many cases, without discrimination. †The total number of tons, in 1889, 1891, 1892 and 1893, under Ammonite, includes blood. ‡Cotton-seed meal.

The Average Retail Prices for 1882, 1884, 1885, 1886, 1887, 1888, 1889, 1890, 1891, 1892 and 1893.

	1882.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.	1893.
Complete Manure	$41.00	$38.00	$35.73	$36.68	$34.80	$34.83	$36.07	$34.64	$34.23	$34.19	$34.11
Ammoniated Superphosphate without Potash (Dissolved Bone, etc)	32.00	31.00	31.62	29.25	32.63	31.90	31.83	32.00	29.64	30.86	31.33
Ground Bone	37.00	36.00	31.25	34.35	35.39	33.76	34.46	32.74	31.99	31.35	32.50
Kainit	12.00	10.00	11.75	10.60	10.25	12.83	12.10	12.23	13.44	13.49	11.43
Muriate of Potash	41.00	38.00	42.15	42.00	39.54	42.33	39.75	41.75	42.05	42.47	41.22
Ammonite	56.00	43.00	43.00	*40.40	....	*36.66	*34.60	31.84	33.00	40.00	45.60
Ammonium Sulphate	99.00	70.50	68.50	70.00	68.20	69.70	71.18	68.63	69.20	66.97	67.28
Sodium Nitrate	76.00	54.00	52.25	58.72	51.61	52.00	51.62	44.83	46.39	44.77	49.27
Blood	56.00	43.50	38.67	....	35.33	....	....	....	33.00	32.67	45.60
Fish	45.00	31.50	34.66	....	35.17	....	....	....	31.08	34.05	34.00
Hair	10.00	11.00	10.00	10.00	....	....	....	....	7.00	....	7.00
Poudrette	10.09	10.00	10.00	10.00	....	....	....	....	....	....	....
Superphosphates with 30 to 40 per cent. Phosphoric Acid	75.00	....	....	....	....	....	....	....	....	....	....
Superphosphates with 11 to 18 per cent. Phosphoric Acid	28.50	24.50	....	....	....	....	....	....	....	....	....
Superphosphates made from Bone Black	34.00	26.00	29.86	25.85	26.95	24.80	24.55	22.00	21.08	20.89	18.98
" " " S. C. Rock	26.60	20.00	20.31	17.75	17.73	15.60	15.80	14.00	15.39	14.50	14.44

*The prices for blood, ammonite and fish have been averaged for the years 1886, 1888 and 1889, for reasons mentioned above.

The question has been raised whether the variations in the average price of complete manures have been accompanied by corresponding variations in the absolute amounts of plant-food actually delivered to consumers. To answer this the analyses made by the Station in the past year have been averaged, with the following results:

	Total Nitrogen.	Total Phos. Acid.	Available Phos. Acid.	Insoluble Phos. Acid.	Potash.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
1893 average of 248 samples......	2.69	10.23	7.54	2.69	4.58
1892 " " 196 "	2.74	10.38	7.70	2.67	4.50
1891 " " 212 "	2.71	10.12	7.29	2.83	4.21
1890 " " 198 "	2.65	10.62	7.70	2.92	4.41
1889 " " 178 "	2.90	10.82	7.88	2.94	4.20
1888 " " 153 "	2.77	10.91	8.09	2.82	4.29
1887 " " 153 "	2.79	10.87	7.69	3.18	4.22
1886 " " 146 "	2.66	10.82	8.07	2.75	3.87
1885 " " 103 "	2.61	11.10	8.33	2.83	3.79

An examination of these figures indicates that no decided change in the average quality of fertilizers has occurred during the past nine years. This is rendered more definite by computing cash valuations on the basis of the Station's schedule for 1893.

On this basis a fertilizer, to represent the average for each of the nine years, would be valued as follows:

1893......	$24.41	per ton.
1892......	24.72	"
1891......	23.89	"
1890......	24.43	"
1889......	25.35	"
1888......	25.21	"
1887......	24.84	"
1886......	24.38	"
1885......	24.51	"

The decline in prices of complete fertilizers from 1885 to 1893, therefore, was not accompanied by a corresponding decrease in the absolute amounts of plant-food delivered to consumers.

The total cash value of the reported sales of commercial fertilizers in this State during 1893, as compared with that of previous years, is as follows:

Total value of fertilizers reported for	1882	$1,070,113.00
" " " " " "	1884	1,369,004.00
" " " " " "	1885	1,116,670.00
" " " " " "	1886	1,181,266.00
" " " " " "	1887	1,022,434.00
" " " " " "	1888	1,125,881.00
" " " " " "	1889	1,106,223.00
" " " " " "	1890	1,247,004.00
" " " " " "	1891	1,346,482.00
" " " " " "	1892	1,509,921.00
" " " " " "	1893	1,641,615.00

II.

THE COMMERCIAL RELATIONS OF FERTILIZERS.

1. Their market prices.

2. The sources and quality of their nitrogen, phosphoric acid and potash, and their economical purchase and rational use.

3. Home mixtures; formulas, composition and cost.

4. The guaranteed chemical composition and relative commercial value of the complete fertilizers sold in the State.

1.

THE MARKET PRICES OF FERTILIZERS.

The preceding records show that the farmers of this State paid nearly $1,300,000 last season for complete manures. It is therefore a matter of importance to ascertain the principal conditions which influence the selling price of these materials.

Complete fertilizers are made by mixing a number of crude products, each of which contains one or more of the following elements, of plant-food, viz., nitrogen, phosphoric acid and potash. Efforts have therefore been made to secure—

The average wholesale prices of nitrogen, phosphoric acid and potash.

The average retail prices of nitrogen, phosphoric acid and potash.

The advance in prices between the wholesale and retail markets.

The wholesale prices are quoted every Monday in the well-known trade journal, *The Oil, Paint and Drug Reporter.* These prices have been tabulated for the entire year, and have then been recalculated in order to express the results in the form adopted by the experiment stations of this country.

The retail prices were calculated from the analyses of those samples of raw materials published in this report, which were taken from goods in the hands of farmers and which had been bought for cash direct from the manufacturers of complete fertilizers.

A comparison of the retail and wholesale prices, secured as above described, gives the following:

	AVERAGE PERCENTAGES BY WHICH THE RETAIL PRICES EXCEED THE WHOLESALE.		
	1891.	1892.	1893.
Nitrogen from Nitrate of Soda	14.0	17.5	26.0
" " Sulphate of Ammonia	7.6	13.0	8.2
" " Dried Blood	36.8	26.9	12.4
" " Dried Fish	....	....	....
" " Ammonite	....	28.8	....
Soluble Phosphoric Acid from Bone Black	....	....	....
" " " " S. C. Rock	73.0	72.2	48.6
Reverted " " " Bone Black	....	....	....
" " " " S. C. Rock	73.0	72.2	48.6
Insoluble " " " Bone Black	....	....	....
" " " " S. C. Rock	....	....	....
Potash from High-Grade Sulphate of Potash	9.3	23.3	21.4
" " Double Sulphate of Potash and Magnesia	26.1	19.6	23.9
" " Kainit	43.2	52.8	25.0
" " Muriate	10.8	10.5	10.8

A summary of these averages for six years shows that the wide difference between wholesale and retail prices of available phosphoric acid, noticed in 1891 and 1892, has been very materially diminished this year, although it is still much too great. In the case of nitrogen the difference has been diminished 6 per cent.; in potash there is also a reduction of 6 per cent.

SUMMARY.

Retail Prices Exceed Wholesale by the Following Percentages.

	1888.	1889.	1890.	1891.	1892.	1893.
Nitrogen..................	11.9	12.5	15.4	10.8	21.6	15.5
Phosphoric Acid............	33.3	48.8	43.6	73.0	72.2	48.6
Potash........................	26.9	16.0	16.5	22.4	26.6	20.3

The data upon which all of the above information depends will be found on the following pages.

THE WHOLESALE PRICES OF NITROGEN, PHOSPHORIC ACID AND POTASH IN CRUDE PRODUCTS.

The table showing the wholesale prices of crude products, as taken from *The Oil, Paint and Drug Reporter*, follows on the next page. From it the tables of wholesale prices of actual plant-food have been calculated upon the basis of the following analyses:

Nitrate of Soda..................................	16	per cent.	Nitrogen.
Sulphate of Ammonia.........................	20½	"	"
Dried Blood and Ammonite.................	12½	"	"
Acid Phosphate..................................	12	"	Available Phosphoric Acid.
High-Grade Sulphate of Potash............	50	"	Potash.
Double Sulphate of Potash and Magnesia,	25	"	"
Muriate of Potash..............................	50	"	"
Kainit..	12½	"	"
Sylvinit...	15	"	"

Nitrogen, Phosphoric Acid and Potash—Wholesale Prices in New York, Per Ton.

MONTHS.	OF NITROGENOUS MATTER.								ACID PHOSPHATE.		OF POTASH SALTS.									
	NITRATE OF SODA.		SULPHATE OF AMMONIA.		AZOTINE.		DRIED BLOOD.				MURIATE OF POTASH.		KAINIT.		SYLVINIT.		DOUBLE SULPHATE OF POTASH AND MAGNESIA.		HIGH-GRADE SULPHATE OF POTASH.	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
January	$44.60	$43.40	$60.40	$59.20	$40.60	$39.69	$39.84	$39.08	$8.10	$7.80	$36.00	$35.00	$9.10	$8.60	$13.07	$12.40	$23.00	$22.00	$42.00	$41.00
February	45.50	44.50	61.75	60.75	45.45	44.69	45.07	44.31	7.65	7.35	36.60	35.60	9.00	8.50	13.07	12.40	23.40	22.40	42.60	41.60
March	48.00	45.75	68.50	67.00	48.67	48.10	49.24	48.48	7.50	7.20	37.80	36.70	9.75	8.50	13.07	12.40	23.40	22.40	42.60	41.60
April	46.75	45.75	65.50	64.50	45.07	44.31	43.93	43.17	7.50	7.20	39.00	37.80	9.75	8.50	13.07	12.40	23.40	22.40	42.60	41.60
May	42.40	39.80	64.00	63.00	41.06	40.30	38.78	37.88	7.50	7.20	39.60	38.40	9.80	8.50	13.07	12.40	23.40	22.40	42.60	41.60
June	36.00	33.90	61.75	60.50	36.93	36.17	35.03	34.27	7.50	7.20	38.00	36.60	9.75	8.50	13.07	12.40	23.40	22.40	42.60	41.60
July	35.40	34.10	64.20	63.20	34.39	33.63	33.03	32.27	7.50	7.20	36.60	35.60	9.75	8.50	13 07	12.40	23.40	22.40	42.60	41.60
August	35.75	33.75	66 00	62.00	33.71	32.95	31.25	30.49	7.50	7.20	36.60	35.60	9.75	8.50	13.07	12.40	23.40	22.40	42.60	41.60
September	35.75	34.25	66.50	62.00	32.00	31.24	30.68	29.92	7.50	7.20	38.00	36.60	9.75	8.50	13.07	12.40	23.40	22.40	42.60	41.60
October	38.40	36.50	72.00	67.40	40.91	40.15	37.88	37.12	7.50	7.20	39.20	37.20	9.75	8.50	13.07	12.40	23.40	22.40	42.60	41.60
November	37.75	36.60	70.05	69.25	41.67	40.91	39.39	38.44	7.50	7.20	40.00	35.60	9.75	8.50	13.07	12.40	23.40	22.40	42.60	41.60
December	37.00	35.10	69.50	64.00	40.39	39.64	38.44	37.68	7.50	7.20	40.00	35.60	9.75	8.50	13.07	12.40	23.40	22.40	42.60	41.60

Wholesale Prices in New York, per Pound, of Plant-Food.

MONTHS.	Wholesale cost per pound of nitrogen in form of—								Wholesale cost ℔ lb. of phosphoric acid in form of—		Wholesale cost per pound of potash in form of—									
	Nitrate of soda.		Sulphate of ammonia.		Azotine.		Dried blood.		Acid phosphate.		Muriate of potash.		Kainit.		Sylvinit.		Double sulphate of potash and magnesia.		High-grade sulphate of potash.	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.
January	13.9	13.6	14.7	14.4	16.2	15.9	15.9	15.6	3 4	3.3	3.6	3.5	3.6	3.4	3.9	3.7	4.6	4.4	4.2	4.1
February	14.2	13.9	15.1	14.8	18.2	17.9	18.0	17.7	3.2	3.1	3.7	3.6	3.6	3.4	3.9	3.7	4.7	4.5	4.3	4.2
March	15.0	14.3	16.7	16.3	19.5	19.2	19.7	19.4	3.1	3.0	3.8	3.7	3.9	3 4	3.9	3.7	4.7	4.5	4.3	4.2
April	14.6	14.3	16.0	15.7	18.0	17.7	17.6	17.3	3.1	3.0	3.9	3.8	3.9	3.4	3.9	3.7	4.7	4.5	4.3	4.2
May	13.3	12.4	15.6	15.3	16.4	16.1	15.5	15.2	3.1	3.0	4.0	3.8	3.9	3.4	3.9	3.7	4.7	4.5	4.3	4.2
June	11.3	10.6	15.1	14.8	14.8	14.5	14.0	13.7	3.1	3.0	3.8	3.7	3.9	3.4	3.9	3.7	4.7	4.5	4.3	4.2
July	11.1	10.7	15.7	15.4	13.8	13.5	13.2	12.9	3.1	3.0	3.7	3.6	3.9	3.4	3.9	3.7	4.7	4.5	4.3	4.2
August	11.2	10.5	16.1	15.1	13.5	13.2	12.5	12.2	3.1	3.0	3.7	3.6	3.9	3.4	3.9	3.7	4.7	4.5	4.3	4.2
September	11.2	10.7	16.2	15.1	12.8	12.5	12.3	12.0	3.1	3.0	3.8	3.7	3.9	3.4	3.9	3.7	4.7	4.5	4.3	4.2
October	12.0	11.4	17.6	16.4	16.4	16.1	15.2	14.8	3.1	3.0	3.9	3.7	3.9	3.4	3.9	3.7	4.7	4.5	4.3	4.2
November	11.8	11.4	17.1	16.9	16.7	16.4	15.8	15.4	3.1	3.0	4.0	3.6	3.9	3.4	3.9	3.7	4.7	4.5	4.3	4.2
December	11.6	11.0	17.0	15.6	16.2	15.9	15.4	15.1	3.1	3.0	4.0	3.6	3.9	3.4	3.9	3.7	4.7	4.5	4.3	4.2
Average for 1893	12.3		15.8		15.9		15.3		3.1		3.7		3.6		3.8		4.6		4.2	
Average for 1892	12.0		14.6		11.8		11.9		3.6		3.8		3.6		3.8		4.6		4.3	
Average for 1891	12.9		15.7		11.4		11.7		3.7		3.7		3.7		3.8		4.6		4.3	

No marked variations in price are noticed, except in the case of the various sources of nitrogen. Nitrate of soda has declined in price from $48 in March to $35.10 in December; sulphate of ammonia has advanced from $59.20 in January to $69.50 in December; azotine and dried blood, while about the same as they were at the beginning of the year, have, nevertheless, during the year, shown wide variations, varying from $31.24 and $29.92 to $48.67 and $49.24, respectively. In all the nitrogenous materials there is an increase in average price per pound, ranging from 0.3 cent in nitrate of soda to 4.1 cents in azotine; the price per pound of acid phosphate has decreased 0.5 cent, while those of the various potash salts have remained practically constant for the last three years.

AVERAGE RETAIL PRICES OF NITROGEN, PHOSPHORIC ACID AND POTASH IN CRUDE PRODUCTS.

With few exceptions, the samples of raw materials published in this report were taken from goods in the hands of farmers and had been bought for cash direct from the manufacturers of complete fertilizers. After an analysis of the samples, therefore, it was not difficult to calculate the retail prices per pound of the various forms of nitrogen, phosphoric acid and potash used in this trade.

The tables in subsequent pages furnish in detail the information gained by this work, and afford data also for the following summary. For comparison, results secured in a similar manner in 1887, 1888, 1889, 1890, 1891 and 1892 are republished:

	1887.	1888.	1889.	1890.	1891.	1892.	1893.
	cts.	cts.	cts.	cts.	cts.	cts.	cts.
Cost per pound of Nitrogen from Nitrate of Soda...	16.0	16.3	16.0	14.2	14.7	14.1	15.5
" " " " " " Sulphate of Ammonia....	16.5	17.0	17.2	16.9	16.9	16.5	17.1
" " " " " " Dried Blood.......	16.4	14.4	20.0	16.0	16.0	15.1	17.2
" " " " " " Dried Fish.........	15.2	15.3	14.9	14 1	14.1	15.2	16.3
" " " " " " Ammonite..........	15.2	15.4	....	....	....	15.2	....
" " " " Soluble Phosphoric Acid from Bone Black................	8.2	7.5	7.4	6.7	6.6	6.5	6.2
" " " " Soluble Phosphoric Acid from S. C. Rock..................	7.5	6.2	6.1	5 6	6.4	6.2	5.5
" " " " Reverted Phosphoric Acid from Bone Black...	8.2	7.5	7.4	6.7	6.6	6.5	6.2
" " " " Reverted Phosphoric Acid from S. C. Rock..................	7.5	6.2	6.1	5.6	6.4	6.2	5.5
" " " " Insoluble Phosphoric Acid from Bone Black................	2.0	1.9	1.8	1.7	....	....	....
" " " " Insoluble Phosphoric Acid from S. C. Rock..................	1.9	1.5	1.5	1.4	....	....	....
" " " " Potash from High-Grade Sulphate..............	5.7	4.7	5.6	5.5	4.7	5.3	5.1
" " " " " " Double Sulphate Potash and Magnesia........	6.2	6.1	6.0	....	5.8	5.5	5.7
" " " " " " Kainit..................	4.0	5.1	4.8	5.0	5.3	5.5	4.5
" " " " " " Muriate	4.1	4.0	3.9	4.2	4.1	4.2	4.1
" " " " " " Sylvinit	....	....	....	5.4	....	....	....

These averages are the *manufacturers' retail cash prices for the nitrogen, phosphoric acid and potash in the crude stock from which complete fertilizers are made.*

COMPARISON BETWEEN THE AVERAGE WHOLESALE AND RETAIL PRICES OF NITROGEN, PHOSPHORIC ACID AND POTASH.

The conclusions reached in regard to the wholesale and retail prices are here tabulated. They represent the manufacturers' *wholesale* and *retail* prices for plant-food *in its best forms.* The percentages by which the retail prices exceed the wholesale have been taken as the basis of the comparison.

	Manufacturers' averages.				Average percentage by which the retail prices exceed the wholesale.		
	Wholesale prices for 1892.	Retail prices for 1892.	Wholesale prices for 1893.	Retail prices for 1893.	1891.	1892.	1893.
	cts.	cts.	cts.	cts.			
Nitrogen from Nitrate of Soda	12.0	14.1	12.3	15.5	14.0	17.5	26.0
" " Sulphate of Ammonia	14.6	16.5	15.8	17.1	7.6	13.0	8.2
" " Dried Blood	11.9	15.1	15.3	17.2	36.8	26.9	12.4
" " Dried Fish	....	15.2	....	16.3	....	....	....
" " Ammonite	11.8	15.2	15.9	....	....	28.8	....
Soluble Phosphoric Acid from Bone Black	....	6.5	....	6.2	....	....	....
" " " " S. C. Rock	3.6	6.2	3.7	5.5	73.0	72.2	48.6
Reverted " " " Bone Black	....	6.5	....	6.2	....	....	....
" " " " S. C. Rock	3.6	6.2	3.7	5.5	73.0	72.2	48.6
Insoluble " " " Bone Black	....	....	....	....	....	....	....
" " " " S. C. Rock	....	....	....	....	....	....	....
Potash from High-Grade Sulphate	4.3	5.3	4.2	5.1	9.3	23.3	21.4
" " Double Sulphate of Potash and Magnesia	4.6	5.5	4.6	5.7	26.1	19.6	23.9
" " Kainit	3.6	5.5	3.6	4.5	43.2	52.8	25.0
" " Muriate	3.8	4.2	3.7	4.1	10.8	10.5	10.8
" " Sylvinit	3.8	....	3.8	....	....	....	....

INCOMPLETE FERTILIZERS AND HOME MIXTURES.

I. *The consumption of fertilizers in the State.*

II. *The preparation of formulas.*

III. *Home mixtures; their mechanical condition, composition and valuation.*

IV. *Comparison of methods of buying fertilizers.*

V. *Trade values of fertilizing ingredients for 1893.*

VI. *Average cost per pound of plant-food constituents.*

VII. *Methods of buying raw materials; chemical analyses.*

I.

The Consumption of Fertilizers in the State.

Each year witnesses an increased use of commercial fertilizers by the farmers of the State, consisting both of the mixtures prepared by manufacturers and of raw fertilizing materials. Statistics gathered by the Station show that the use of mixed fertilizers has more than doubled in the last ten years, while the use of raw or unmixed materials, not including ground and dissolved bone, has increased about 40 per cent. The figures are as follows:

Mixed fertilizers sold in 1882	15 941	tons.
" " " " 1892	33,821	"
Increase	17,880	"
Unmixed fertilizing materials sold in 1882	6,081	tons.
" " " " " 1892	8,544	"
Increase	2,463	"

The total value of all reported sales in 1882 was $1,070,113 and in 1892, $1,509,921, an increase in 1892 over 1882 of $439,808.

It is observed that the value of the sales made in 1892 is proportionately much less than in 1882. The decrease in cost is due in large part to three causes—first, to the increased supply of raw materials, particularly the nitrogenous salts and phosphates; second, to improved methods in the handling and manufacture of raw materials, and third, to a better knowledge of fertilizing materials and their proper use, both on the part of the manufacturer and the consumer. The fact still remains, however, that the cost of fertilizers is a very considerable item in the expenditures of the farmer; it is, therefore, of great importance, in order to make economical purchases, that he should have very definite knowledge as to what constitutes value in a fertilizer and of his own particular needs.

II.

The Preparation of Formulas.

While it is now pretty generally understood that the value of a fertilizer depends upon the amount and kind of nitrogen, phosphoric acid and potash contained in it, on the whole the value of definite proportion of these elements, for the different crops, is not so clear.

The evidence given by the manufacturers themselves indicates that even they do not agree as to what constitutes perfect proportions, since, in nearly all cases, their special formulas for the various crops are radically different, yet they uniformly insist that their own formula—for potatoes, for instance—is perfect for all conditions of soil and season, and will work equally well everywhere. Such claims have no foundation in fact.

For general farming it is evident that it is more frequently a question of amount of plant-food applied, rather than the proportions in which the different elements exist in a mixture. Still there are many good reasons for the preparation of special formulas for the different crops, special not only in amount but in kind of plant-food furnished. Our own experiments have shown this repeatedly. For instance, it has been shown that early tomatoes require, for the best results, not only an abundance of nitrogen, but that the nitrogen shall be in quickly-available forms. A formula, therefore, which contained a high percentage of nitrogen, derived from slowly-available organic forms, would not be likely to give as good results as one which contained a lower percentage, existing in the form of nitrates.

Plants have also been classified as to their special needs for plant-food, and it is a useful classification, yet it seems that there should be a still further subdivision, since it frequently happens that the element which is specifically useful when the object is the largest mature plant, is not the one that is most useful when the object is a rapid early growth rather than maturity. Furthermore, the kind of soil is an important factor, soils of equal quality in respect to contained plant-food not responding uniformly to equal applications of the same forms of fertilizer constituents. In the preparation of formulas, therefore, regard should be had to the character of soil, whether rich or poor, heavy or light, dry or wet; the method of the growth, whether for quick and partial, or slow and full development. The character of the farming, too, should be regarded. It is obvious that heavy applications of quickly-available and relatively costly forms of plant-food would be less likely to prove profitable in general or extensive farming than in specific and intensive, though in all methods of farm practice there is some one crop regarded as more profitable than another. In such cases, frequent applications of different fertilizers may be avoided, if, by heavy applications of good materials, the more profitable crop is made as large as conditions of

season and climate will permit, trusting to the residues of plant-food left by it to bring forward the others in a rotation to a maximum.

The duplication of formulas may be avoided, too, by the preparation of what may be termed a basic formula; that is, one rich in all the fertilizer constituents, without particular reference to any single element, this being applied heavily upon some one crop in the rotation, the other crops being furnished with such specific elements as they may require. Assuming, for instance, that the rotation is the common one, of corn, potatoes, wheat and hay, a rational fertilization, and one which would be likely to be quite as useful as any, would be as follows: For corn, 300 pounds per acre of a mixture made up of 200 pounds of S. C. rock superphosphate and 100 pounds of muriate of potash, and such barnyard manure as may be available, all applied broadcast.

For potatoes, apply as a minimum one-half ton per acre of a mixture made up as follows:

Nitrate of soda	200	pounds.
Sulphate of ammonia	200	"
Tankage (ground fine)	200	"
Bone-black or S. C. rock superphosphate	1,000	"
High-grade sulphate of potash	400	"
	2,000	"

At least two-thirds of this mixture should be applied broadcast, the remainder evenly over the row at time of planting. For wheat and timothy, apply, in early spring, a dressing of from 100 to 200 pounds per acre of nitrate of soda.

By this method of fertilization, the potatoes, frequently the best-paying crop, would be supplied with sufficient plant-food of all kinds to insure a maximum growth, under normal conditions of season and average conditions of soil, and would leave a considerable residue, particularly of mineral constituents, available for the wheat and hay; the total amount of fertilizer constituents, added in the rotation, would also be more than sufficient to supply the maximum needs of all the crops, thus insuring a gradual increase in fertility. This system may also be adopted where more intensive methods are practiced, such crops as tomatoes, onions, beets, turnips, cabbage, etc., receiving the constituents particularly useful in forcing early growth, the others being supplied by heavy applications of the basic formula.

For fruit trees, vines and similar slow growths, the basic formula may consist of a mixture made up of two parts of ground bone and one of muriate or sulphate of potash. Nitrate of soda should supply the extra nitrogen required, which experience has found to be necessary after the bearing period has begun.

One of the best-producing peach orchards in the State, now 10 years old, and still healthy and vigorous, has received a yearly application of 1,000 pounds per acre of this mixture and 200 pounds per acre of nitrate of soda during the period of bearing.

FORMULAS USED IN MAKING THE MIXTURES.

No. 5036. John S. Collins.

200	lbs. of Nitrate of Soda.
200	" " Sulphate of Ammonia.
400	" " Peter Cooper's Bone.
400	" " Bone-Black Superphosphate.
600	" " S. C. Rock Superphosphate.
200	" " Muriate of Potash.
2000	

No. 5090. Runyon Field.

200	lbs. of Nitrate of Soda.
400	" " Tankage.
1000	" " Dissolved Bone.
400	" " Muriate of Potash.
2000	

No. 5166. M. S. Crane.

150	lbs. of Nitrate of Soda.
200	" " Sulphate of Ammonia.
300	" " Ground Bone.
900	" " Bone-Black Superphosphate.
450	" " High-Grade Sulphate of Potash.
2000	

No. 5254. Monmouth Co. Grange.

200	lbs. of Nitrate of Soda.
200	" " Sulphate of Ammonia.
800	" " Bone-Black Superphosphate.
400	" " S. C. Rock Superphosphate.
200	" " Muriate of Potash.
200	" " High-Grade Sulphate of Potash.
2000	

No. 5253. J. H. Denise.

200	lbs. of Nitrate of Soda.
150	" " Sulphate of Ammonia.
50	" " Cotton-Seed Meal.
400	" " Dissolved Bone.
400	" " Bone-Black Superphosphate.
400	" " S. C. Rock Superphosphate.
200	" " High-Grade Sulphate of Potash.
200	" " Muriate of Potash.
2000	

No. 5147. Swedesboro Grange.

200	lbs. of Nitrate of Soda.
200	" " Sulphate of Ammonia.
400	" " Peter Cooper's Bone.
400	" " Bone-Black Superphosphate.
600	" " S. C. Rock Superphosphate.
200	" " Muriate of Potash.
2000	

No. 5176. Charles Tindall.

300	lbs. of Nitrate of Soda.
800	" " Ground Bone.
500	" " Bone-Black Superphosphate.
400	" " Muriate of Potash.
2000	

No. 5182. Amos Gardiner.

300	lbs. of Nitrate of Soda.
700	" " King Crab.
300	" " Peter Cooper's Bone.
500	" " Bone-Black Superphosphate.
200	" " Muriate of Potash.
2000	

No. 5435. D. D. Denise.

200	lbs. of Nitrate of Soda.
200	" " Sulphate of Ammonia.
200	" " Ground Bone.
1000	" " Bone-Black Superphosphate.
200	" " Muriate of Potash.
200	" " High-Grade Sulphate of Potash.
2000	

No. 5499. John A. Layton.

200	lbs. of Nitrate of Soda.
1000	" " Dissolved Bone.
200	" " Muriate of Potash.
600	" " Hen Manure.
2000	

III.

Home Mixtures; Their Mechanical Condition, Composition and Valuation.

With one exception the home mixtures here reported were made up from high-grade materials, and may be regarded rather as basic, in the sense already stated, than as mixtures for special crops, though in many cases the formulas were adopted after a study of the requirements of soil and crop in the section in which they are used. Chemical analyses were made of all the materials used in the mixtures, and are all included in this report.

The Fineness of the Mixtures.

It has been stated in our previous reports that the samples of home mixtures, as well as manufactured brands, were, on the whole, fine, dry and of good mechanical condition. It is claimed by manufacturers and dealers, however, that a farmer with his ordinary farm appliances cannot get that degree of fineness in his mixtures which is so essential for ease of handling and the best distribution of the material.

Mechanical condition, though of unquestionable value, is a relative term; that is, fineness in a mixture which has been made from materials containing the fertilizer constituents in relatively-insoluble forms, is evidently of greater importance than fineness in a mixture which has been made from materials containing easily-soluble and readily-available constituents.

In our studies this year this point was made a matter of actual investigation. All the samples of home mixtures examined, 10 in number, were subjected to a mechanical analysis, and as a means of comparison 12 samples representing the leading brands of different manufacturers were also included. The standard of fineness or perfect mechanical composition was made one twenty-fifth of an inch in diameter; that is, the condition was regarded as perfect if all of the material passed through a sieve, the holes of which were one twenty-fifth of an inch in diameter. The fineness of the samples examined is given in the following table:

	Home Mixtures.				Manufacturers' Mixtures.		
	FINER THAN		COARSER THAN		FINER THAN		COARSER THAN
	$\frac{1}{25}$ in.	$\frac{1}{12}$ in.	$\frac{1}{12}$ in.		$\frac{1}{25}$ in.	$\frac{1}{12}$ in.	$\frac{1}{12}$ in.
No.	per cent.	per cent.	per cent.	No.	per cent.	per cent.	per cent.
5036......	89	7	4	1......	86	9	5
5090......	70	24	6	2......	81	12	7
5147	83	10	7	3......	85	10	5
5166......	92	5	3	4......	80	16	4
5176......	73	15	12	5......	78	17	5
5182......	71	14	15	6......	81	14	5
5253......	90	7	3	7......	79	14	7
5254......	74	21	5	8	76	17	7
				9......	69	21	10
5435......	78	17	5	10......	71	22	6
				11......	74	17	9
5499......	68	19	13	12......	65	24	11

Of the home mixtures it is observed that in two cases only did the samples approach closely to perfection, 90 per cent. and over in each case being finer than one twenty-fifth of an inch in diameter; in one case the fineness fell below 70 per cent.

In the manufacturers' mixtures the greatest fineness reached was 86 per cent.; though on the whole the samples were very uniform, in two cases the fineness fell below 70 per cent. The average fineness of the whole number of samples in each lot is as follows:

Home Mixtures.			Manufacturers' Mixtures.		
FINER THAN		COARSER THAN	FINER THAN		COARSER THAN
$\frac{1}{25}$ in.	$\frac{1}{12}$ in.	$\frac{1}{12}$ in.	$\frac{1}{25}$ in.	$\frac{1}{12}$ in.	$\frac{1}{12}$ in.
per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
79	14	7	77	16	7

The statement heretofore made in reference to the condition of both home mixtures and manufacturers' mixtures seems from this study to have been well founded, though it is further shown that farmers using the ordinary appliances of the farm do make from the supplies of raw materials regularly on sale in the markets, better mixtures than the manufacturers.

The superior mechanical condition of the manufacturers' mixtures, so strongly urged by interested parties, is not sustained by this investigation.

The study of the composition of these mixtures, as bearing upon this matter of condition, is also instructive. The State law requires that only the potash soluble in water shall be determined in commer-

cial fertilizers; hence, on the same basis of mechanical condition, home mixtures and manufacturers' mixtures are equal in respect to the availability of potash. In the case of nitrogen and phosphoric acid, however, both the soluble and insoluble forms are taken into consideration. The soluble nitrogen, for instance, in all cases consists largely of nitrates and ammonia salts, while the organic or insoluble nitrogen may be derived from a whole series of products, ranging from dried blood to ground horn and hoof; the distribution and availability of the former being practically but little influenced by fineness, while the availability of the latter is in direct ratio to the fineness. In the case of phosphoric acid the mechanical condition determines to a certain extent the possible availability of that shown by analysis to be insoluble.

Of the total nitrogen in the home mixtures examined, 72 per cent. consists of nitrates and ammonia salts, and of the total phosphoric acid 80 per cent. is available. Of the total nitrogen in the manufacturers' mixtures, but 28 per cent. consists of nitrates and ammonia salts, while 75 per cent. of the total phosphoric acid is available.

It is evident that mechanical condition, so far as it has a bearing on availability, particularly of nitrogen, may be far more important in one mixture than in another. Fineness affects but 28 per cent. of the nitrogenous materials contained in the home mixtures, while in the manufacturers' mixtures it affects 72 per cent.

The claim that farmers cannot secure good mechanical condition in their mixtures must therefore have reference to the use of low-grade materials, rather than to those used in the home mixtures reported. It is admitted that low-grade materials do require the use of machinery for grinding and manipulation in order to secure the requisite fineness.

Composition of Home Mixtures.

The actual analyses of the different mixtures are given in the following table. The cost of the materials used in making them is also compared with the estimated commercial value of the mixture at Station's valuation:

TABLE OF ANALYSES.

Station Number.	Nitrogen. From Nitrates.	Nitrogen. From Ammonia Salts.	Nitrogen. From Organic Matter.	Phosphoric Acid. Soluble in Water.	Phosphoric Acid. Soluble in Citrate of Ammonia.	Phosphoric Acid. Insoluble.	Phosphoric Acid. Total Available.	Potash.	Cost per Ton.	Valuation at Station's Prices.	Value Exceeds Cost.
5036	1.86	1.92	0.42	8.80	2.16	2.34	10.96	4.96	$30.00	$33.42	$3.42
5090	1.38	0.18	2.16	4.28	4.10	1.83	8.38	10.69	30.70	33.69	2.99
5147	1.59	1.85	0.54	8.28	2.11	2.61	10.39	5.45	27.29	32.56	5.27
5166	0.81	2.18	1.12	7.76	1.76	1.44	9.56	11.78	35.83	39.76	3.93
5176	2.56	0.11	1.41	3.22	4.33	6.24	7.55	9.22	30.47	33.87	3.40
5182	2.42	0.25	2.61	3.34	4.04	2.31	7.38	7.13	31.02	34.42	3.40
5253	1.38	1.44	0.68	6.26	0.51	0.93	6.77	13.68	28.21	33.06	4.85
5254	1.21	1.73	0.45	8.86	0.16	0.25	9.02	10.44	29.40	33.20	3.80
5435	1.46	2.09	0.93	8.86	0.91	0.26	9.77	9.61	32.15	37.04	4.89
5499	2.34	0.12	0.94	3.50	1.05	1.77	4.55	10.60	21.90	27.12	5.22

The chemical analyses of these mixtures compare very favorably with their theoretical composition, calculated from the analyses of the raw materials, and from the weights used in the formulas, and thus verify the claim that farmers, using the ordinary tools of the farm, do make even mixtures of fertilizing materials.

It will be observed that with the one exception where hen manure was used as a base, all of these mixtures are high grade, the average composition being higher than the average of the same number of brands, selected as the highest from the whole number of different manufactured brands now on the market. This matter of concentration is too little appreciated by the farmers, and the relatively low grade of manufactured brands is due in no small degree to a demand on their part for goods at a low cost per ton.

Ton prices alone are not a safe guide in the purchase of mixed fertilizers.

The average composition of all the complete fertilizers or manufacturers' mixtures, examined by the Station last year, and the average of the home mixtures of this year, are as follows:

	Nitrogen. per cent.	Available Phosphoric Acid. per cent.	Potash. per cent.
Manufacturers' Mixtures	2.74	7.70	4.50
Home Mixtures	**4.02**	**8.44**	**9.36**

Assuming that the proportions of plant-food are as good in one case as in the other, and that there were as many tons of high-grade as of low-grade brands sold, we can get some idea of the financial importance of concentration.

There were sold in 1892, 33,821 tons of complete fertilizer; each ton contained on the average 299 pounds of actual available nitrogen, phosphoric acid and potash; each ton of the home mixtures contains on the average 436 pounds of actual available plant-food. If, therefore, manufacturers' mixtures had contained as much actual food as the home mixtures, the total amount sold last year would have been contained in 23,172 tons, instead of 33,821 tons, or a difference of 10,649 tons; that is, the 10,649 tons of material mixed, bagged, freighted and sold as part of the various brands, contained no plant-food whatever, and was, therefore, entirely useless. It was shown in Bulletin 89, of this Station, that the charges of the manufacturers for mixing, bagging, shipping and other expenses were $8.53 per ton. Since it costs no more to mix, bag, freight and sell a high-grade mixture than a low-grade, the cost to the farmers for handling this worthless material amounted in 1892 to $90,835. It has been shown by the work of this Station, that the average composition of mixed fertilizers and the fixed charges of the manufacturers have not materially changed in the last ten years. The total sales reported during this time were 247,000 tons, containing, on the same basis of comparison, 77,000 tons of worthless material, which cost farmers over $656,000, and from which they could expect no returns whatever. The manufacturers are not altogether to blame for this state of affairs; they aim to supply the demands of their trade, which are too often for cheap goods.

Concentration or highness of grade is also important from the standpoint of quality of plant-food; fertilizers of a low composition must be made either from high-grade materials to which make-weight has been added, or from low-grade materials. This may be illustrated by the average quality of the complete fertilizers on the market. If made from high-grade materials the following quantities would furnish the actual plant-food present, the nitrogen drawn equally from the three forms, nitrates, ammonia salts and organic matter:

	Quantity of materials.	Furnishing pounds of Nitrogen.	Phosphoric Acid.	Potash.
Nitrate of soda	115 lbs.	18.3	......	......
Sulphate of ammonia	90 "	18.3	......	......
Dried blood, or ammonite	152 "	18.2	......	......
Bone-black superphosphate	963 "	......	15.4	......
Muriate or sulphate of potash	180 "	......	......	90
Total	1,500 "	54.8	15.4	90
Per cent		2.74	7.70	4.50

It is observed from this statement that it would be necessary to add 500 pounds of make-weight to each ton. That the materials used in making the complete fertilizers are not all high grade is evidenced by the fact that less than one-half of the brands contain more than one form of nitrogen, viz., organic, and that nearly all of them contain a very considerable percentage of insoluble phosphoric acid.

Cost of Home Mixtures.

These home mixtures represent the purchase of about 700 tons; the average cost is $29.70, and the valuation $33.81, or a gain of $4.11 over Station's prices, which are intended to represent the retail cash cost of fertilizer constituents in the raw materials at factory. The cost of these mixtures may perhaps be better represented by showing the actual cost per pound of the different constituents. Using the average composition of the mixtures and the Station's schedule of prices as factors, the result is as follows:

Nitrogen, 14.9 cents; available phosphoric acid, 5.7 cents, and potash, 4 cents per pound. By this same method of calculation the average cost per pound of the constituents in complete fertilizers sold in 1892 is shown to be:

Nitrogen, 24.8 cents; available phosphoric acid, 9.4 cents, and potash, 6.7 cents per pound. If the constituents in the average home mixture this year had been bought at these figures the cost per ton would have been $49.27. This not only illustrates the impossibility of getting at true values by comparison on the ton basis alone, but shows the economy in buying raw fertilizing materials in the open market, and for cash. The difference of $19.50 per ton, applied to the 700 tons represented, makes a total of $13,699. This is certainly a good return for cash payments instead of credit, for selecting mate-

rials suited to the needs of the soil and plant, instead of buying hit or miss, and for using the regular labor of the farm in mixing, instead of paying others who do the work no better.

IV.

Comparison of Methods of Buying Fertilizers.

This Station does not maintain that it is always better to buy raw materials and mix at home than to buy the manufacturers' brands, though the studies made here give strong evidence that by so doing money can be saved. This method presupposes in all cases a definite knowledge on the part of the buyer of the sources of supply, of market conditions and of his own particular needs. With such knowledge at command farmers can buy mixtures very much cheaper on the whole than they are now secured. There may be, and doubtless are, too, many cases in which it is preferable, even at a higher cost, to buy manufacturers' brands instead of raw materials. A great many farmers object to mixing at home, others to the bother of buying at a distance, and nearly all to paying cash, and to avoid one or all of these inconveniences, and at the same time to do business in a more business-like way, they buy direct from the manufacturer mixtures prepared to their order. Three samples, representing goods bought by this method by the Coopertown Farmers' Club, were received by the Station this year. Their examination furnishes intering data in reference to methods of buying. The mechanical condition of two samples was good, the third was wet and pasty, the average condition of the three being much lower than that shown by the home mixtures or manufactured brands. The average content of soluble nitrogen is greater than that contained in the manufactured brands, and less than that in the home mixtures, being 56 per cent. as against 28 per cent. in the manufactured brands, and 72 per cent. in the home mixtures.

Mechanical Analyses.

No.	Finer than $\frac{1}{25}$ in. per cent.	Finer than $\frac{1}{12}$ in. per cent.	Coarser than $\frac{1}{12}$ in. per cent.
5061	74	17	9
5062	82	10	8
5063	45	43	12
Average	67	23	10

The average composition of these brands is much lower for all the constituents than the average of the home mixtures, and lower in nitrogen than the average of the mixed fertilizers, sold in 1892; with the possible exception of the organic nitrogen, the quality of the materials used was good.

TABLE OF ANALYSES.

Station Number.	Nitrogen. From Nitrates.	Nitrogen. From Ammonia Salts.	Nitrogen. From Organic Matter.	Phosphoric Acid. Soluble in Water.	Phosphoric Acid. Soluble in Citrate of Ammonia.	Phosphoric Acid. Insoluble.	Phosphoric Acid. Total Available.	Potash.	Cost per Ton.	Valuation at Station's Prices.	Value Exceeds Cost.
5061	1.48	0.28	1.76	7.04	0.77	1.50	7.81	7.39	$32.00	$29.10	—$2.90
5062	0.78	0.11	1.03	7.36	1.21	1.61	8.57	3.18	20.00	21.04	+1.04
5063	1.18	0.16	0.33	6.92	0.65	1.36	7.57	9.27	28.00	24.09	—3.91

The average cost per ton is $26.66, and the average valuation $24.74, or a cost $1.92 per ton higher than the Station's valuation. The average cost per pound of the constituents is 18.5 cents for nitrogen, 7 cents for available phosphoric acid, and 5 cents for potash. If the average cost per pound of the elements contained in the home mixtures were applied, the cost would be $22.02 per ton, or $4.64 less than was actually paid; that is, these farmers paid the manufacturers $4.64 per ton for mixing an average-grade fertilizer. If the amount of plant-food contained in one ton of a mixture of this brand had been bought in the usual manner, through local dealers, and on credit, the cost would have been $35.57, or $8.91 greater than was actually paid. This method of buying, while it is shown to be less desirable than the buying of materials and mixing at home, since the mechanical condition is poorer, the composition lower, and the price higher, is a great improvement on the general method now commonly practiced.

V.

Trade Values of Fertilizing Ingredients for 1893.

At a meeting of Stations' Directors and Chemists, the following schedule was arranged for use in Connecticut, Massachusetts, Rhode Island and New Jersey during the season of 1893:

***Schedule of Trade Values Adopted by Experiment Stations for 1893.**

	Cts. per pound.
Nitrogen in Ammonia Salts	17
" " Nitrates	15½
Organic Nitrogen in dried and fine ground fish, meat and blood and in mixed fertilizers	17½
" " " castor pomace and cotton-seed meal	16½
" " " fine ground bone and tankage	15
" " " fine-medium bone and tankage	12
" " " medium bone and tankage	9
" " " coarser bone and tankage	7
" " " horn shavings, hair and coarse fish scrap	7
Phosphoric Acid, soluble in water	6½
" " " " ammonium citrate*	6½
" " insoluble, in fine bone and tankage	6
" " " " fine-medium bone and tankage	5
" " " " medium bone and tankage	4
" " " " coarser bone and tankage	3
" " " " mixed fertilizers	2
" " " " fine ground fish, cotton-seed meal, castor pomace and wood ashes	5
Potash as High-grade Sulphate, and in forms free from Muriates (or Chlorides)	5½
" " Muriate	4½

Valuation of Fertilizing Ingredients in Fine Ground Feeds.

Organic Nitrogen	16½
Phosphoric Acid	5
Potash	5½

The Station's prices for nitrogen in ammonia salts and for available phosphoric acid were slightly reduced this year, owing to the lower wholesale quotations which ruled for materials containing them during the six months preceding the adoption of the schedule. For similar reasons the prices for nitrogen in nitrates and organic forms increased. No changes were made in the prices of the various potash salts.

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*The solubility of phosphates, in ammonium citrate solutions, is seriously affected by heat. An Act of the Legislature (see Laws of New Jersey, 1874, page 90) provides that in this determination the temperature used shall not exceed 100°.Fah.; in Connecticut, Rhode Island and Massachusetts 150° Fah. has been adopted. The higher the temperature the larger will be the percentage of phosphoric acid dissolved by ammonium citrate solutions, and the larger the amount of this so-called "reverted" phosphoric acid in a ton of superphosphate the lower will be the price per pound of said acid. Consequently the Station's valuations of phosphoric acid, soluble in ammonium citrate, have been fixed at *six cents per pound* for Connecticut, Massachusetts and Rhode Island, and at *six and one-half cents per pound* for New Jersey.

VI.

The Average Cost Per Pound of Plant-Food Constituents.

The average cost per pound of the nitrogen, phosphoric acid and potash, as secured from the tables of analyses, may be fairly assumed to represent the manufacturers' retail prices at factory, and admit of a comparison with the Station's schedule of valuations, which are intended to represent the retail cash cost per pound of the fertilizing ingredients contained in the raw materials before they are mixed to form complete fertilizers.

A study of the following table shows that the Station's schedule agrees closely with the manufacturers' averages for nitrogen and potash, while the Station's prices for available phosphoric acid are 11 per cent. greater than the prices at which farmers have bought direct from the manufacturers. The average cost per pound of the nitrogen and phosphoric acid, in the different grades of bone and tankage, is also compared with the Station's schedule, and is shown to agree very closely:

COMPARISON BETWEEN STATION'S SCHEDULE AND MANUFACTURERS' AVERAGE RETAIL PRICES OF PLANT-FOOD IN FERTILIZER SUPPLIES.

	MANUFACTURERS' AVERAGE RETAIL PRICES FOR		STATION'S SCHEDULE OF PRICES FOR
	1892.	1893.	1893.
	cts.	cts.	cts.
Cost per pound of Nitrogen from Nitrate of Soda	14.1	15.5	15½
" " " " " " Sulphate of Ammonia	16.5	17.1	17
" " " " " " Dried Blood	15.1	17.2	17½
" " " " " " Dried Fish and Ammonite	15.2	16.3	17½
" " " " " " Cotton-Seed Meal	....	14.9	16½
" " " " " " Dissolved Bone	....	16.0	17½
" " " " fine ground bone and tankage	....	14.1	15
" " " " fine-medium bone and tankage	....	11.3	12
" " " " medium bone and tankage	....	8.4	9
" " " " coarse bone and tankage	....	6.6	7
" " " " Available Phosphoric Acid from Bone Black	6.5	6.2	6½
" " " " " " " " S. C. Rock	6.2	5.5	6½
" " " " " " " " Dis'd Bone	....	6.0	6½
" " " " Insoluble in fine ground bone and tankage	....	5.6	6
" " " " " " fine-medium bone and tankage	....	4.7	....
" " " " " " medium bone and tankage	....	3.8	4
" " " " " " coarse bone and tankage	....	2.8	3
" " " " " " Potash from High-Grade Sulphate	5.3	5.1	5½
" " " " " " " " Double Sulph's of Pot. and Mag.	5.5	5.7	5½
" " " " " " " " Kainit	5.5	4.5	4½
" " " " " " " " Muriate	4.2	4.1	4½

VII.

Methods of Buying Raw Materials; Chemical Analyses.

The samples analyzed represent materials bought by farmers' clubs or individuals direct from the manufacturers of complete fertilizers, or from large dealers in fertilizer supplies. A full list of these firms with their business addresses is always published in the annual reports of this Station.

The nitrogen salts, with the exception of No. 5169, the superphosphates and the potash salts, were found by analysis to reach their guarantees, to be of good quality and reasonably uniform in composition; the variations in cost per ton being, as a rule, accompanied by corresponding changes in the cost per pound of the fertilizing elements. In standard goods, when average composition is assumed, the price per ton has, as in the past, proved a safe guide as to the actual cost per pound of the element contained. The safest and most satisfactory method of buying is, however, that which makes guaranteed composition or the unit system the basis of contracts.

The variations in cost of materials were chiefly due to the time of buying and the quantity bought. Quotations made on goods bought early in the year, particularly nitrogenous materials, were very much lower than those ruling when the season's work had fully begun and the demand for materials had become more pressing. Prices for car lots of the different materials were from 5 to 10 per cent. lower than when ton lots were purchased.

As a rule, quotations were based upon ton lots. Special rates proved to be no lower than when such claims were not made.

These facts emphasize the importance of a knowledge of the quality of the various materials, the sources of supply and the market conditions.

Summary of Practical Conclusions.

1. That the use of fertilizers in the State is increasing, and that the present annual expenditure of over $1,500,000 may be very materially reduced by a definite knowledge of what and how to buy.

2. That in the preparation of formulas the quality of plant-food is of prime importance, and that the proportion of the different elements, as well as the amount of the application, should be determined by the object of their use.

3. That farmers can make mixtures which are equal to the best manufactured brands and superior to the average—first, in mechanical condition; second, in concentration; third, in quality, and fourth, in point of cost.

4. That in buying manufacturers' mixtures distinct advantages in quality and cost are secured when bought direct from the manufacturers instead of from local agents.

5. That the trade values of fertilizing ingredients adopted by the Station are a fair basis for estimating commercial values of manufacturers' mixtures.

6. That sources of supply, time of buying and quantity bought, are the main conditions influencing cost per pound of plant-food in standard fertilizing materials.

FORMS OF NITROGEN

Readily and Completely Soluble in Water.

NITRATE OF SODA

Furnishing Nitrogen in Form of Nitrates.

Station Number.	FROM WHOM RECEIVED.	Percentage of Nitrogen.	Cost of Nitrogen per lb.	Cost of 2,000 lbs. of Nitrate of Soda.
			cts.	
5028	Moorestown Grange	15 90	14.5	$46 00
5113	Dennis Crane, Roselle	16.18	18.5	*60 00
5076	Purchased by Station	15.75	15.9	50 00
5086	Runyon Field, Bound Brook	16.17	14.5	47 00
5139	Swedesboro Grange.	15.45	14.9	46 00
5150	J. H. Denise, Freehold	15.87	14.5	46 00
5161	M. S. Crane, Caldwell	15.96	16.3	52 00
5167	Charles Tindall, Middletown	15.75	15.9	50 00
5177	Amos Gardiner, Mullica Hill	15.92	17.3	55 00
5183	I. W. Nicholson, Camden	15.93	17.5	*56 00
5207	G. S. Voorhees, Mine Brook	16.03	15.4	49 50
5290	Chas. Kraus, Egg Harbor City	15 84	17.4	*54 00
5436	Geo. A. MacBean, Lakewood	16.18	15.5	50 00
5466	J. M. White, New Brunswick	15.97	15.7	50 00
5467	Parsippany Grange	15.81	14.9	47 00
5524	John A. Layton, Liberty Corner	15.81	16.4	52 00
Average Cost per pound of Nitrogen in Nitrate of Soda			15.5	

*Retail price at point of consumption.

SULPHATE OF AMMONIA

Furnishing Nitrogen in Form of Ammonia.

Station Number.	FROM WHOM RECEIVED.	Percentage of Nitrogen.	Cost of Nitrogen per lb.	Cost of 2,000 lbs. of Sulphate of Ammonia.
			cts.	
5029	Moorestown Grange	20.30	16.5	$67 10
5140	Swedesboro Grange	20.22	16.6	67 10
5151	J. H. Denise, Freehold	20.16	15.6	63 00
5162	M. S. Crane, Caldwell	19.77	18.3	72 50
5168	Charles Tindall, Middletown	19 98	16.8	67 00
5169	" " "	17.95	18.7	67 00
Average Cost per Pound of Nitrogen in Sulphate of Ammonia			17.1	

FORMS OF NITROGEN INSOLUBLE IN WATER

Furnishing Nitrogen in Form of Organic Matter.

DRIED BLOOD.

Station Number.	FROM WHOM RECEIVED.	Percentage of Nitrogen.	Cost of Nitrogen per lb.	Cost of 2,000 lbs. of Dried Blood.
			cts.	
5077	Purchased by Station	11.52	**20.6**	$47 50
5170	Charles Tindall, Middletown	12.42	**19.7**	48 90
5297	Chas. Kraus, Egg Harbor City	11.94	**17.2**	41 00
5500	Theo. F. D. Baker, Bridgeton	12.88	**17.5**	45 00
5298	Chas. Kraus, Egg Harbor City	10.67	***10.8**	25 00
Average Cost per Pound of Nitrogen in Dried Blood			**17.2**	

* Contains 1.91 per cent. phosphoric acid.

DRIED AND GROUND FISH.

Station Number.	FROM WHOM RECEIVED.	Percentage.		Cost Per Pound.		Cost of 2,000 lbs. of Fertilizer.
		Nitrogen.	Phosphoric Acid.	Nitrogen.	Phosphoric Acid.	
				cts.	cts.	
5179	Amos Gardiner, Mullica Hill	9.48	1.06	**14.9**	5.0	*$29 50
5291	Chas. Kraus, Egg Harbor City	8.72	7.77	**17.3**	5.0	†38 00
5292	" " " " "	7.46	7.61	**20.4**	5.0	†38 00
5293	" " " " "	5.73	10.14	**19.9**	5.0	†33 00
5311	I. W. Nicholson, Camden	5.43	9.43	**15.3**	5.0	26 00
5501	Theo. F. D. Baker, Bridgeton	7.01	8.58	**18.8**	5.0	35 00
Average Cost per Pound of Nitrogen in Dried and Ground Fish.				**16.3**		

* King Crab.

† Retail price at point of consumption.

COTTON-SEED MEAL.

Station Number.	FROM WHOM RECEIVED.	Percentage.			Cost Per Pound.			Cost of 2,000 lbs. of Fertilizer.
		Nitrogen.	Phosphoric Acid.	Potash.	Nitrogen.	Phosphoric Acid.	Potash.	
					cts.	cts.	cts.	
......	D. D. Denise, Freehold	6.72	3.74	1.99	**14.9**	5.0	5.5	$26 00

GROUND BONE AND TANKAGE.

Station Number.	FROM WHOM RECEIVED.	Mechanical Analysis. Finer than $\frac{1}{50}$ in.	Finer than $\frac{1}{25}$ in.	Finer than $\frac{1}{12}$ in.	Coarser than $\frac{1}{12}$ in.	Percentage. Nitrogen.	Phosphoric Acid.	Cost of 2,000 lbs. of Fertilizer.
......	Average of three samples........................	54	17	15	14	1.74	29.24	$23 33
5158	J. H. Denise, Freehold........................	93	7	....	....	3 23	21.52	27 50
5163	M. S. Crane, Caldwell........................	46	50	4	....	3.78	23.99	28 00
5175	Chas. Tindall, Middletown....................	54	23	18	8	3.50	23.95	27 75
5088	Runyon Field, Bound Brook..................	49	30	16	5	6.13	9.24	25 50
5141	Theo. Brown, Swedesboro......................	77	11	7	5	6.18	16.85	37 00
5299	Charles Kraus, Egg Harbor City.............	38	31	13	18	7.45	5.66	30 00
5502	Theo. F. D. Baker, Bridgeton................	46	22	21	11	5.81	13.87	33 00

GROUND BONE AND TANKAGE.

Station Number.		Cost of Nitrogen per lb. in— Finer than $\frac{1}{50}$ in.	Finer than $\frac{1}{25}$ in.	Finer than $\frac{1}{12}$ in.	Coarser than $\frac{1}{12}$ in.	Cost of Phosphoric Acid per lb. in— Finer than $\frac{1}{50}$ in.	Finer than $\frac{1}{25}$ in.	Finer than $\frac{1}{12}$ in.	Coarser than $\frac{1}{12}$ in.
		cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.
......	Ground Bone (Peter Cooper's)............	10.0	8.0	6 0	4.7	4.0	3.3	2.7	2.0
5158	" "	11.5	9.2	6.9	5.4	4.6	3.8	3 1	2.3
5163	" "	11.5	9.2	6.9	5.4	4.6	3 8	3.1	2.3
6175	" "	12.2	9.8	7.3	5.7	4.9	4.1	3.2	2.4
5088	Tankage..	15.0	12.0	9.0	7.0	6.0	5.0	4.0	3.0
5141	"	15.5	12.4	9.3	7.2	6.2	5.1	4.1	3.1
5299	"	19.5	15.6	11.7	9.1	7 8	6.5	5.2	3.9
5502	"	17.5	14.0	10 5	8.2	7.0	5.8	4.7	3.5
Average Cost per Pound..................		**14.1**	**11.3**	**8.4**	**6.6**	**5.6**	**4.7**	**3.8**	**2.8**

DISSOLVED BONE AND NITROGENOUS SUPERPHOSPHATES.

Station Number.	FROM WHOM RECEIVED.	PERCENTAGE. Nitrogen.	Phosphoric Acid. Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Available.	Cost per Pound. Nitrogen.	Available Phosphoric Acid.	Cost of 2,000 Pounds of Fertilizer.
							cts.	cts	
5060	Coopertown Farmers' Club.......	2.12	10.66	0.80	1.61	11.46	**15.6**	5.9	$20 00
5087	Runyon Field, Bound Brook....	2.30	7.94	7.71	0.87	15.65	**15.4**	5.7	25 00
5157	J. H. Denise, Freehold............	1.82	5.46	3.37	2 62	8.83	**13.7**	5.0	*
5470	Parsippany Grange..................	2.48	8.80	4.58	3.12	13.38	**17.5**	6.5	26 00
5525	John A Layton, Liberty Corner.	1.92	6.68	1.61	3.60	8.29	**18.1**	6.7	18 00
Average Cost per Pound of Nitrogen....................................							**16.1**	6.0	

* Ammonia, $2.25 per unit; Available Phosphoric Acid, $1 per unit.

PLAIN SUPERPHOSPHATES

Furnishing Soluble, Reverted and Insoluble Phosphoric Acid,

MANUFACTURED FROM

BONE BLACK, BONE ASH, ETC., ETC.

Station Number.	FROM WHOM RECEIVED.	Phosphoric Acid.				Cost of Available per lb.	Cost of 2,000 lbs. of Fertilizer.
		Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Available.	cts.	
5031	Moorestown Grange	13.80	....	0.04	13.80	5.8	*
5081	Purchased by Station	15.28	0.53	0.43	15.81	6.3	$20 00
5143	Swedesboro Grange	13.72	....	0.18	13.72	5.8	*
5148	J. M. White, New Brunswick	13.18	0.55	1.11	13.73	6.6	18 25
5152	J. H. Denise, Freehold	14.92	0.07	0.19	14.99	6.3	19 00
5164	M. S. Crane, Caldwell	15.46	....	0.20	15.46	7.3	22 50
5171	Chas. Tindall, Middletown	13.00	0.64	0.79	13.64	5.6	15 40
5180	Amos Gardiner, Mullica Hill	12.42	4.95	0.40	17.37	5.8	20 00
5294	Chas. Kraus, Egg Harbor City	14.30	0.39	1.83	14.69	8.7	†24 00
5468	Parsippany Grange	16.74	0.15	0.13	16 89	5.9	20 00
5503	Theo. F. D. Baker, Bridgeton	16.60	0.15	0.08	16.75	6.9	23 00
Average Cost per Pound of Phosphoric Acid						6.2	

* $1.15 per unit of Available Phosphoric Acid.
† Retail price at point of consumption.

SOUTH CAROLINA ROCK AND OTHER MINERAL PHOSPHATES.

Station Number.	FROM WHOM RECEIVED.	Phosphoric Acid.				Cost of Available per pound.	Cost of 2,000 lbs. of Fertilizer.
		Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Available.	cts.	
5032	Moorestown Grange	14 06	1.76	1.30	15.82	4.9	*
5069	H. I. Budd, Mount Holly	10.88	1.99	1.78	12.87	6.8	$17 50
5082	Purchased by Station	11.96	2.08	1.41	14.04	4.3	12 00
5144	Swedesboro Grange	12.04	1.29	2.17	13.33	4.9	*
5153	J. H. Denise, Freehold	12.92	0.12	1.36	13.04	4.4	11 50
5295	Chas. Kraus, Egg Harbor City	9.70	1.71	4.02	11.41	9.6	†22 00
5437	Geo. A. MacBean, Lakewood	10.96	1.64	2.27	12.60	6.7	17 00
5469	Parsippany Grange	10.54	1.73	1.51	12.27	5.3	13 00
5504	Theo. F. D. Baker, Bridgeton	9.98	1.70	4.03	11.68	6.8	16 00
Average Cost per Pound of Phosphoric Acid						5.5	

* $0 98 per unit of Available Phosphoric Acid.
† Retail price at point of consumption.

GERMAN POTASH SALTS

Readily Soluble in Distilled Water.

MURIATE OF POTASH.

Station Number.	FROM WHOM RECEIVED.	Percentage of Potash.	Cost of Potash per lb.	Cost of 2,000 lbs. of Muriate.
			cts.	
5035	Moorestown Grange	48.25	4.2	$41 00
5084	Purchased by Station	49.98	4.3	42 50
5089	Runyon Field, Bound Brook	51.47	4.1	42 00
5145	Swedesboro Grange	48.84	4.2	41 00
5155	J. H. Denise, Freehold	52.65	3.8	40 00
5172	Charles Tindall, Middletown	48.46	4.1	40 00
5181	Amos Gardiner, Mullica Hill	50.20	4.0	40 00
5184	I. W. Nicholson, Camden	50.76	4.3	*44 00
5185	" " "	48.53	5.2	*50 00
5296	Chas. Kraus, Egg Harbor City	51.90	4.5	*46 50
5471	Parsippany Grange	49.89	4.0	40 00
5526	John A. Layton, Liberty Corner	51.52	4.3	44 50
Average Cost per Pound of Potash in Muriate			4.1	

*Retail price at point of consumption.

KAINIT.

Station Number.	FROM WHOM RECEIVED.	Percentage of Potash.	Cost of Potash per lb.	Cost of 2,000 lbs. of Kainit.
			cts.	
5018	John W. Kline, New Village	13.67	3.7	$10 25
5085	Purchased by Station	12.70	4.3	11 00
5146	Swedesboro Grange	12.66	4.9	12 41
5149	J. M. White, New Brunswick	12.46	4.4	11 00
5156	J. H. Denise, Freehold	11.25	6.7	*15 00
5186	I. W. Nicholson, Camden	12.40	5.2	*13 00
5208	G. S. Voorhees, Mine Brook	11.70	5.3	12 50
Average Cost per Pound of Potash in Kainit			4.5	

*Retail price at point of consumption.

DOUBLE SULPHATE OF POTASH AND MAGNESIA.

Station Number.	FROM WHOM RECEIVED.	Percentage of Potash.	Cost of Potash per lb.	Cost of 2,000 lbs. of Double Sulphate.
			cts.	
5174	Charles Tindall, Middletown	25.41	5.7	$29 00

GERMAN POTASH SALTS

Readily Soluble in Distilled Water.

HIGH-GRADE SULPHATE OF POTASH.

Station Number.	FROM WHOM RECEIVED.	Percentage of Potash.	Cost of Potash per lb.	Cost of 2,000 lbs. of High-Grade Sulphate.
			cts.	
5033	Moorestown Grange	49.19	5.2	$51 50
5083	Purchased by Station	48.29	5.7	55 00
5165	M. S. Crane, Caldwell	50.00	4.6	46 00
5173	Charles Tindall, Middletown	50.49	5.0	50 00
5154	J. H. Denise, Freehold	50.85	4.5	46 00
5527	J. M. White, New Brunswick	45.88	5.4	50 00
5528	" " " "	48.06	5.2	50 00
Average Cost per Pound of Potash in High-Grade Sulphate			5.1	

4.

COMPLETE FERTILIZERS.

THE GUARANTEED CHEMICAL COMPOSITION AND RELATIVE COMMERCIAL VALUES OF FERTILIZERS.

An act to regulate the manufacture and sale of fertilizers.

[Laws of New Jersey for 1874, page 90.]

1. That every commercial fertilizer which shall be offered for sale in this state shall be accompanied by an analysis, stating the percentage therein of ammonia, or its equivalent of nitrogen; of potash, in any form or combination, soluble in distilled water; and of phosphoric acid in any form or combination; the portion of phosphoric acid soluble in distilled water; that portion soluble in a neutral solution of citrate of ammonia at a temperature not exceeding one hundred degrees Fahrenheit; and that portion of phosphoric acid not soluble in either of the above-named fluids, shall each be determined separately; and the material from which the phosphoric acid is obtained shall also be stated; a legible statement of such analysis shall accompany all packages or lots of over one hundred pounds sold, offered or exposed for sale.

5. That any person selling, offering or exposing for sale any commercial fertilizer without the analysis required by the first section of this act, or the act to which this act is a supplement, or with an analysis stating that said fertilizer contains a larger percentage of any one or more of the constituents mentioned in said section than is contained therein, shall forfeit fifty dollars for the first offense and one hundred dollars for each subsequent offense; *provided further*, that the provisions of this section, or the act to which this act is a supplement, shall not apply to any manure sold at a price not exceeding one-half a cent per pound, nor to any imported guanos.

THE GUARANTEED CHEMICAL COMPOSITION OF FERTILIZERS.

From the Station's standpoint this subject involves—

1st. The sampling.
2d. The selection of samples.
3d. The chemical analysis.

Previous to the year 1884 all samples of fertilizers analyzed in this laboratory were drawn either by the Station's officials or by reputable farmers who had reasons for suspecting the quality of the brands bought for their own use. This system had many disadvantages and has been abandoned. At present the only samples received for analysis are those taken by duly-authorized Inspectors.

This plan has been satisfactory to both consumers and producers, for the Inspectors are farmers of the highest standing, who undertake the work solely because it is regarded as a matter of vital interest to the farming community.

The names of those who have represented the Station during the past season are as follows:

Charles Kraus	Egg Harbor City	Atlantic county.
Jacob B. Eckerson	River Vale	Bergen county.
H. I. Budd	Mount Holly	Burlington county.
I. W. Nicholson	Camden	Camden county.
J. H. Richardson	Rio Grande	Cape May county.
T. F. D. Baker	Bridgeton	Cumberland county.
Wm. R. Ward	Newark	Essex county.
J. C. Griscom	Woodbury	Gloucester county.
Augustus Dilts	Copper Hill	Hunterdon county.
Franklin Dye	Trenton	Mercer county.

J. M. White	New Brunswick	Middlesex county.
J. H. Denise	Freehold	Monmouth county.
J. J. Mitchell	Troy Hills	Morris county.
Geo. A. MacBean	Lakewood	Ocean county.
J. H. Schoonmaker	Richfield	Passaic county.
Woodnutt Pettit	Salem	Salem county.
G. S. Voorhees	Mine Brook	Somerset county.
D. N. Warbasse	Huntsburg	Sussex county.
Dennis C. Crane	Westfield	Union county.
W. O. Ward	Huntsburg	Warren county.

At the beginning of the season each Inspector was furnished with a sampling tube, blanks for describing samples, bottle labels, etc., together with printed instructions regarding their use, and each Inspector was requested to secure a sample of every brand of complete fertilizer which he could find in his district. As fast as samples were found they were shipped to the Station, where they were properly numbered and stored.

A copy of the instructions, under which all samples were taken, is as follows:

DIRECTIONS TO BE FOLLOWED IN SAMPLING FERTILIZERS.

Inspectors may sample fertilizers found either—

First—Upon farms;
Second—In dealers' storehouses; or
Third—In manufactories.

The Station prefers that samples should be drawn either upon farms or in dealers' storehouses.

In sampling fertilizers found upon farms, Inspectors should ascertain—

First—That the samples are not taken from stock of a past season or from stock which is or has been carelessly stored.
Second—That they were received in good condition; and have since been so stored that a noticeable gain or loss of moisture has been prevented.

In sampling from *dealers' storehouses*, Inspectors should also ascertain whether the fertilizers are of old (last season's) or of new stock. Preference should always be given to the present season's goods. Circumstances may, however, make it advisable to sample old stock; in such cases, this fact must be distinctly stated by the Inspector, in his report to the Station's Director.

If for any reason it is found to be necessary to draw samples at factories, Inspectors should decline—

First—To sample from piles of fertilizers.
Second—To sample from bags which are not distinctly marked with the brand, the manufacturer's name and the guaranted analysis.

If fertilizers are found stored in piles only, Inspectors should cause six or more bags to be filled from different portions of the piles; from these bags the samples may be drawn in the usual manner.

Whenever the mechanical condition will allow, samples should be drawn by means of the *sampling tube* furnished by the Station.

It is not desirable to sample lots of less than one-half ton of any one brand. In such small lots portions may be taken from each bag; in large lots each fifth or tenth bag may be opened. The several portions representing the same brand should then be carefully mixed and a quart fruit jar filled, securely closed and marked with labels furnished by the Station.

As soon as a sample has been taken, and *invariably* before bags of another brand have been opened, the Inspector should carefully fill out the blank describing samples.

He should copy *from the bags*—

> *First*—The brand.
> *Second*—The name of the manufacturer.
> *Third*—The guaranteed analysis.

Other information needed for the description must be got from the owner of the fertilizer.

Each sample bottle should be separately wrapped in heavy paper, and packed for transportation in a wooden box, properly closed. This box should be forwarded by express, directed to

THE NEW JERSEY AGRICULTURAL EXPERIMENT STATION,
New Brunswick, N. J.

FERTILIZERS.

Form for Description of Sample.

In taking fair average samples, such as will justly represent the manufacturer as well as the consumer, it is very important that every precaution be taken, so that in case of a suit at law, the person signing the description can testify to its accuracy. The writing should be plain and legible. The filled-out form, if wrapped with the sample, will serve as a label. If any printed circular, pamphlet, analysis or statement accompanies the fertilizer, or is used in its sale, send a copy with the specimen.

1. Brand of fertilizer..
2. Name and address of manufacturer..

....

3. Name and address of dealer from whose stock this sample is taken.....................

....

4. Date of taking this sample...
5. Selling price per ton, hundred, bag or barrel..
6. Selling weight claimed for each package weighed...
7. Actual weight of packages opened..

8. Copy of analysis or composition affixed to packages of this fertilizer..................
....
....
....

9. Signature..

(To be signed in every case by the person taking sample.)

P. O. Address..

THE SELECTION OF SAMPLES.

The methods followed in this laboratory have been developed gradually ever since the Station was organized; very slight modifications only have been introduced during the past year.

Each spring a circular letter is addressed to the fertilizer manufacturers, requesting a list of all brands intended for the New Jersey trade. The returns are properly classified and arranged in such a manner that brands which Inspectors fail to find are known, and special searches for them can be instituted promptly.

As above stated, Inspectors are requested to sample all fertilizers offered for sale in their counties. Many duplicates are consequently received at New Brunswick, all of which are numbered, however, and an entry is made for each in an appropriate book.

CHEMICAL ANALYSIS.

The chemical analysis includes a test for the three forms of nitrogen, viz., as nitrates, as ammonia salts and as organic matter, and a quantitative determination of each when found. In all cases the total, soluble, reverted and insoluble phosphoric acid are determined. Potash and chlorine determinations are made in each sample, and the potash found in excess of that needed to form muriate of potash, with the chlorine present, is credited to the manufacturer as sulphate of potash.

This complete examination of each sample is of value in furnishing information regarding the kind and quality of the materials used in mixed fertilizers.

The section of the fertilizer law published as an introduction to this chapter, indicates that certain analyses must be made in this State according to prescribed methods; all others are left to the judgment

of the chemists, and are those recommended by the Association of Official Agricultural Chemists.

The rules of this laboratory require that all determinations shall be made in duplicate, and that duplicates shall not be made upon the same day.

During the past year two bulletins containing fertilizer analyses have been published:

No. 93. Devoted to Home-Mixed Fertilizers and Fertilizing Materials.

No. 97. Devoted to Complete Fertilizers, Ground Bone and Miscellaneous Samples.

The circulation of these publications approximated 16,000 copies of each in this State alone.

The purpose of analyzing unmixed materials and home mixtures is to direct attention to the character and composition of standard fertilizer supplies, and to show the actual cost per pound of the constituents contained in them, though it also suggests economical methods of buying plant-food, gives useful formulas, and shows that farmers can make mixtures which, in mechanical condition, concentration and quality, are equal to the best manufactured brands upon the market. It shows how direct savings may be made in the purchase and use of fertilizing materials.

The analyses which follow have reference almost entirely to products manufactured from the supplies indicated on previous pages. The actual and guaranteed composition of manufactured brands are compared, which shows whether the manufacturer fulfills his claims, and how far the guarantee given is a guide as to the actual composition. The application of the schedule of values, adopted for the various kinds and forms of fertilizer constituents, also shows whether the guarantee of a brand warrants the selling price attached, and the commercial value of the different brands studied in connection with their composition, permits of a fair comparison of the charges of the different manufacturers for mixing, bagging and selling their goods.

The value of this work to the intelligent consumer is direct, in furnishing definite information as to the composition and value of the different brands forced upon his attention, and of indirect value to all consumers in that it reduces to a minimum the amount of worthless products offered for sale.

Inspection of Fertilizers.

It is the aim of the Station to secure a sample of all the different brands and fertilizer products upon the market. It is believed that this aim has been practically attained this year; the number of brands of complete fertilizers is nearly 20 per cent. greater, while the number of those of a miscellaneous character is quite as great as in any previous year. This result is due both to a closer inspection and to the fact that new brands are constantly introduced, the product of both old and new firms. For instance, it is shown that while eleven firms entirely new to the State are represented by one or more brands, one manufacturer is represented by 14 brands, another by 13, and eight are represented by 8 or more brands.

It is also shown by the results of analyses that in many cases the main difference in a brand is a difference in the selling price attached, the amount and proportion of plant-food constituents apparently being a less important factor to the manufacturer than selling price.

While the multiplication of brands is not on the whole to be commended, a point worthy of consideration is shown, viz., that where dealers have brands made to their order by regular manufacturers the quality is always good and the commercial value is much nearer the selling price than those sold direct by the manufacturer himself.

Commercial Valuation.

The schedule of values adopted and used in the valuation of complete fertilizers this year, as well as that of 1892, is added.

	1892. cts.	1893. cts.
Nitrogen from Nitrates	15	15½
" " Ammonia Salts	17½	17
" " Organic Matter	16	17½
Phosphoric Acid, Soluble	7½	6½
" " Reverted	7½	6½
" " Insoluble	2	2
Potash as Muriate	4½	4½
Potash free from Muriates	5½	5½

The change in the schedule by the lowering of values for available phosphoric acid, and nitrogen as ammonia, and increasing those of both organic and nitrate nitrogen, makes the valuation per ton on the

same basis of analyses slightly lower this year than in 1892. The analysis of unmixed materials, however, showed that the schedule was entirely just to the manufacturer.

Composition of Fertilizers.

The brands examined this year in most cases contain an equivalent of plant-food guaranteed, though many brands show evidences of imperfect mixing or carelessness in fixing the guarantee. A guarantee means nothing to the farmer from the standpoint of proportion and amount of plant-food, unless the analysis corresponds to that guarantee.

In two cases, Nos. 5361 and 5623, the State law, which requires that a guaranteed analysis shall accompany each package of fertilizer for sale, was ignored. Sample No. 5361 is a poudrette, and is of a low-grade character. No. 5623 is of still lower grade, containing six-tenths of one per cent. of nitrogen, about one per cent. of available phosphoric acid, and but a trace of potash, and with a commercial value of only $3.92 per ton, though the selling price is $15. It may not have been the intention of the manufacturers in either case to defraud consumers, though ignorance of the law or of the constituents that constitute value in fertilizers is no valid excuse for the sale of such product without complying with the law; the actual result is, particularly in case of No. 5623, that farmers who buy the product are cheated. Neither is it any excuse that farmers cheat themselves in the purchase of fertilizers, by a careless comparison or no comparison of guarantee and selling price.

A case of this kind may be illustrated by sample No. 5577. The guarantee calls for, even at the best interpretation, but $8.52 worth of actual plant-food, while the selling price is $30 per ton. The law does not fix the selling price, and purchasers should study the relation of these two factors.

Selling Price.

As has been the custom in the past, the selling price of the different brands entered in the tables is the price at which they are sold where sampled. These prices do, of course, vary somewhat, though the variation is between reasonably narrow limits. The average price is found in some cases to be lower, and in others to be higher than those

given in the table. The average composition, selling price and commercial valuation for 1892 and 1893 are shown in the following tabulation:

	Total Nitrogen.	Total Phos. Acid.	Available Phos. Acid.	Insoluble Phos. Acid.	Potash.	Selling Price.	Station Valuation.
1892.........	2.74	10.38	7.70	2.67	4.50	$34.19	$25.66
1893.........	2.69	10.23	7.54	2.69	4.58	34.11	24.41

The average composition and selling price per ton are practically identical with those of last year, while the valuation this year is $1.25 less than in 1892, making the difference between valuation and selling price $9.70, or the selling price 40 per cent. greater than the valuation, which represents the average charges per ton for mixing, bagging and selling. It is evident that the decrease in the cost of fertilizer supplies has not resulted in a lower selling price per ton for the mixtures made from them by the manufacturers. It is shown, too, from a study of the tables, that the difference between valuation and selling price in nearly half of the brands is above this average, ranging from $10 to $25 per ton, thus giving a wide opportunity for selection on the part of the purchaser.

Ground Bone.

The samples of ground bone examined this year are, on the whole, of good character. A criticism made prominent in previous discussions of the analyses of bone products, however, still holds good, namely, that the trade terms, bone meal, pure bone, steamed bone and raw bone, bear no exact relation to the kind of bone, nor do they indicate the method of manufacture. Sample No. 5054 is called a steamed bone. It contains as much nitrogen as the average sample of ground bone, but less than half as much phosphoric acid as is contained in a pure bone. The simple steaming of bone would not have a tendency to decrease the amount of phosphoric acid, but rather to increase it. Samples Nos. 5020 and 5071 are also good examples of products that contain much less of both nitrogen and phosphoric acid than would be contained in pure bone, whatever the method of manufacture. That the manufacturers did not regard the samples as pure is evident from the guarantee which accompanied the brands. In all cases, very much less, particularly of the phosphoric acid, was guaranteed than is known to be present in a pure bone.

A guarantee of less than 4 per cent. of ammonia and 20 of phosphoric acid, or its equivalent in bone phosphate of lime, may well create a suspicion that the product is not a pure bone. Samples Nos. 5556 and 5558 contain potash. While a mixture of bone and potash may be a very effective and profitable manure for general farming, the results of the analyses of these samples indicate that farmers would do better to purchase the bone and potash separately rather than together, as in these brands.

Valuations.

The schedule of prices used in computing values in 1892 and 1893, as well as the average per cent. of fineness of the bone, are added:

	Average per cent. of Fineness.		Nitrogen. Per Pound.		Phosphoric Acid. Per Pound.	
	1892.	1893.	1892.	1893.	1892.	1893.
Finer than $\frac{1}{50}$ in.	38	43	15c.	15c.	7c.	6c.
" " $\frac{1}{25}$ "	28	27	12c.	12c.	$5\frac{1}{2}$c.	5c.
" " $\frac{1}{12}$ "	24	20	$9\frac{1}{2}$c.	9c.	$4\frac{1}{2}$c.	4c.
Coarser " $\frac{1}{12}$ "	10	10	$7\frac{1}{2}$c.	7c.	3c.	3c.

This year the value of the nitrogen in the coarser grades is reduced one-half cent per pound, while the phosphoric acid is reduced in all cases except the coarser grade. The average per cent. of fineness is this year an improvement over that secured in 1892. The average selling price per ton, excluding those samples not comparable, is $32.50, and the average valuation $31.23 per ton.

Miscellaneous Fertilizing Materials.

The analyses of samples of dissolved bone contained in the table on page 101 are shown to be of good quality. The commercial valuations of three out of the five samples bought in the usual manner, by the ton, are within $3 of their selling price. Sample No. 5621 was bought on the basis of $2 per unit for ammonia and $1 per unit for available phosphoric acid. The cost, delivered at consumer's depot, including bags, freight, etc., was 14.3 cents for nitrogen and 5.3 cents for phosphoric acid. These figures for organic nitrogen and available phosphoric acid are 18 per cent. less than the Station's valuations. While the valuation of the other brands is relatively high, the cost per pound of the nitrogen and the phosphoric acid is in every case greater than the Station's valuations. Dissolved bone is an excellent fertilizer for wheat, and at the present low price of this cereal it is of

the greatest importance that farmers should take advantage of such opportunities as are afforded by these products to reduce the cost of the crop. Sample No. 5598 is evidently a mixture of ground bone and dissolved S. C. rock superphosphate, and is an expensive product at the selling price given. In sample No. 5060 the superphosphate has been improved by the addition of sulphate of ammonia, and doubtless would serve a good purpose as a wheat fertilizer.

The samples called dissolved bone and potash do not contain dissolved bone, but dissolved S. C. rock to which potash has been added. While good, they are not cheap sources of phosphoric acid and potash. Sample No. 5622 was bought on the unit basis and in car-load lots. The price paid was 85 cents per unit, or 4¼ cents per pound for available phosphoric acid. This is but another illustration of the advantages to be derived from buying fertilizing materials on the unit basis and in large lots for cash.

The samples of wood ashes examined this year were, with two exceptions, below the average quality. The schedule of values adopted for ashes is 5 cents for phosphoric acid and 5½ for potash. The average cost per pound for potash and phosphoric acid contained in these samples, not including 5562, is 9.7 and 10.7 cents, respectively. While the agricultural value of wood ashes is recognized, it is a question whether farmers do well in purchasing phosphoric acid and potash in this form at the prices named.

In addition to the samples, 105 in number, reported upon preceding pages, the analyses may be found in the following tables of—

248 samples of Complete Fertilizers.
23 samples of Ground Bone.
6 samples of Dissolved Bone.
23 samples of Miscellaneous Products.

The following list may be used as an index to the tables of

COMPLETE FERTILIZERS.

LIST OF MANUFACTURERS WHOSE BRANDS HAVE BEEN SAMPLED AND ANALYZED THIS YEAR.

The Acme Fertilizer Co........Maspeth, L. I.
Allentown Manufacturing Co........Allentown, Pa.
H. J. Baker & Bro........No. 215 Pearl St., New York City.
Baugh & Sons Co........No. 20 S. Delaware Ave., Philadelphia, Pa.
The Berg Co........Port Richmond, Philadelphia, Pa.
Bowker Fertilizer Co........No. 27 Beaver St., New York City.
Bradley Fertilizer Co........No. 92 State St, Boston, Mass.
Brown & Gilman........No. 10 S. Delaware Ave., Philadelphia, Pa.
The Chemical Co. of Canton........No. 36 S. Charles St., Baltimore, Md.

The Chicopee Guano Co..........................No. 140 Maiden Lane, New York City.
Clark's Cove Fertilizer Co..............................No. 81 Fulton St., New York City.
E. Frank Coe Co.......................................No. 16 Burling Slip, New York City.
Crocker Fertilizer and Chemical Co......................No. 56 Pearl St., Buffalo, N. Y.
L. B. Darling Fertilizer Co..Pawtucket, R. I.
Davidge Fertilizer Co................................No. 121 Front St., New York City.
H. W. Doughten..East Moorestown, N. J.
Farmers' Fertilizer Co...Syracuse, N. Y.
J. C. Fifield & Sons..Bakersville, N. J.
Fithian & Pennell...Bridgeton, N. J.
Geo. B. Forrester.....................................No. 169 Front St., New York City.
Garrison & Minch..Bridgeton, N. J.
Theodore Glazer..Linden, N. J.
Great Eastern Fertilizer Company...Rutland, Vt.
H. B. Griffings' Sons & Co........................No. 70 Cortlandt St., New York City.
Hassinger Fertilizer Co...Philadelphia, Pa.
S. M. Hess & Bro...Reading, Pa.
Wm. T. Hill...Copper Hill, N. J.
T. P. Hopler & Co...Belvidere, N. J.
S. H. Howitz..................................No. 2 Chestnut St., Philadelphia, Pa.
Imperial Guano Co..Norfolk, Va.
L. D. Jones..Red Bank, N. J.
Kuhl & Johnson...Flemington, N. J.
E. J. Lampson..Bordentown, N. J.
Lewis & Co..Smyrna, Del.
Lister's Agricultural Chemical Works...Newark, N. J.
Lord & Polk Chemical Co..Odessa, Del.
Frederick Ludlam...............................No. 140 Maiden Lane, New York City.
The Mapes F. and P. Guano Co........................No. 143 Liberty St., New York City.
Milsom Rendering and Fertilizer Co..........No. 997 William St., East Buffalo, N. Y.
Jos. A. Minch & Son...Bridgeton, N. J.
Mitchell Fertilizer Works..Tremley, N. J.
Newark Chemical Works..Newark, N. J.
Newark Fertilizer Co..Newark, N. J.
Newark Poudrette Co.......................................Clifford St., Newark, N. J.
James E. Otis...Tuckerton, N. J.
Parker & Co..Mullica Hill, N. J.
Moro Phillips Chemical Co........................No. 131 S. Third St., Philadelphia, Pa.
Preston Fertilizer Co..Greenpoint, L. I.
The Quinnipiac Co......................................No. 83 Fulton St, New York City.
Read Fertilizer Co.......................................No. 88 Wall St., New York City.
Edward Rigg, Jr..Burlington, N. J.
Scott Fertilizer Co..Elkton, Md.
Shanley & Van Brunt...............................No. 1429 Market St., Philadelpnia, Pa.
Sharpless & Carpenter........................No. 114 S. Delaware Ave., Philadelphia, Pa.
M. L. Shoemaker & Co..............Delaware Ave. and Venango St., Philadelphia, Pa.
John I. Smith Fertilizer Co..Trenton, N. J.
Susquehanna Fertilizer Co..Baltimore, Md.
The Taylor Provision Company...Trenton, N. J.
I. P. Thomas & Son Co..........................No. 2 S. Delaware Ave, Philadelphia, Pa.
Jas. M. Thorburn & Co......................................No. 15 John St., New York City.
Trenton Bone Fertilizer Co...Trenton, N. J.
The J. E. Tygert Co...........................No. 42 S. Delaware Ave., Philadelphia, Pa.
The Tygert-Allen Fertilizer Co.......................No. 2 Chestnut St., Philadelphia, Pa.
Wm. R. Van Gilder...Petersburgh, N. J.
Walker, Stratman & Co......................................No. 45 Third St., Alleghany, Pa.
Walton & Whann..Wilmington, Del.
Geo. M. Wells ....Moorestown, N. J.
J. Wenderoth & Sons..................................No. 1046 Cooper St., Camden, N. J.
Wm. E. Whann..Atglen, Pa.
Williams & Clark Fertilizer Co..........................No. 81 Fulton St., New York City.
F. B. Young..Pennington, N. J.

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.	BRAND.	MANUFACTURER.	SAMPLED BY.	Station Number.
5378	Fertilizer No. 1	Acme Fertilizer Co., Maspeth, L. I.	James H. Schoonmaker, Richfield.	5378
5379	Fertilizer No. 2	" " " " "	" " "	5379
5590	Complete Bone Phosphate	Allentown Manufacturing Co., Allentown, Pa.	J. M. White, New Brunswick.	5590
5233	Potato Manure	H. J. Baker & Bro., New York City.	J. H. Denise, Freehold.	5233
5530	Corn Manure	" " " "	W. O. Ward, Hainesburg.	5530
5545	Cabbage Manure	" " " "	Dayton N. Warbasse, Huntsburg.	5545
5382	Asparagus Manure	" " " "	James H. Schoonmaker, Richfield.	5382
5419	Onion Manure	" " " "	J. H. Denise, Freehold.	5419
5546	Vegetable and Vine Manure	" " " "	Dayton N. Warbasse, Huntsburg.	5546
5381	"A. A." Ammoniated Superphosphate	" " " "	James H. Schoonmaker, Richfield.	5381
5116	Animal Bone and Potash	Baugh & Sons Co., Philadelphia, Pa.	H. I. Budd, Mount Holly.	5116
5115	Special Potato Manure	" " " " "	" " " "	5115
5444	Electric Special Potato Guano	The Berg Co., Philadelphia, Pa.	Woodnutt Pettit, Salem.	5444
5052	Electric $35 Potato Manure	" " " " "	H. I. Budd, Mount Holly.	5052
5260	Electric Lymph Guano	" " " " "	Charles Kraus, Egg Harbor City.	5260
5211	Electric $25 Bone Manure	" " " " "	James C. Griscom, Woodbury.	5211
5259	Electric $30 Cyclone Bone Manure	" " " " "	Charles Kraus, Egg Harbor City.	5259

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.		Nitrogen.					Phosphoric Acid.							Potash.		Chlorine.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Factory.	Selling Price of 2,000 lbs. at Consumers' Depot.	Station Number.
		From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Available. Found.	Available. Guaranteed.	Found.	Guaranteed.					
5378	Acme Fertilizer, No. 1	......	2.08	1.48	3.56	3.69	4.60	2.57	2.02	9.19	....	7.17	8.00	7.92	9.00	3.84	$30.08	....	$43.00	5378
5379	" " No. 2	......	2.54	1.71	4.25	4.92	4.80	3.70	1.87	10.37	....	8.50	8.00	5.08	5.00	3.32	31.14	....	43.00	5379
5590	Allentown Complete Bone Phos	......	0.15	1.37	1.52	1.64	3.48	3.75	4.04	11.27	11.00	7.23	10.00	2.03	2.00	2.09	18.16	....	36.00	5590
5233	Baker's Potato Manure	0.88	2.98	0.99	4.85	3.28	3.74	1.13	1.78	6.65	....	4.87	5.75	11.41	10.00	2.80	35.18	....	40.00	5233
5530	" Corn Manure	0.14	3.06	0.93	4.13	4.10	4.66	1.54	1.70	7.90	....	6.20	6.25	9.57	7.00	3.16	32.52	....	42.00	5530
5545	" Cabbage Manure	0.58	2.78	0.93	4.29	4.73	2.40	3.05	2.45	7.90	....	5.45	5.00	7.70	7.00	5.43	29.61	....	44.00	5545
5382	" Asparagus Manure	0.29	2.80	1.41	4.50	4.10	4.20	1.37	2.28	7.85	....	5.57	6.00	8.16	9.00	4.26	31.36	....	45.00	5382
5419	" Onion Manure	......	3.70	0.81	4.51	4.92	4.14	1.00	0.84	5.98	....	5.14	4.50	10.64	9.00	6.68	32.38	....	42.50	5419
5546	" Vegetable and Vine Manure	......	1.13	0.67	1.80	1.64	2.80	2.07	2.40	7.27	....	4.87	5.50	13.12	12.00	4.16	26.81	....	37.50	5546
5381	" A. A. Ammon. Superphos	0.28	1.03	1.11	2.42	2.46	10.36	1.32	1.02	12.70	11.00	11.68	10.00	3.24	2.00	4.73	26.78	....	37.50	5381
5116	Baugh's Animal Bone and Potash	......	0.54	1.43	1.97	1.64	7.14	2.11	3.05	12.30	5.50	9.25	8.00	2.14	2.00	1.57	22.02	....	27.00	5116
5115	" Special Potato Manure	......	0.26	1.73	1.99	1.64	5.64	1.31	2.37	9.32	....	6.95	5.00	10.22	10.00	9.67	26.12	....	30.00	5115
5444	Berg's Electric Special Potato	......	0.26	2.75	3.01	3.28	4.40	4.04	2.09	10.53	10.50	8.44	8.50	7.19	7.00	1.45	29.85	....	40.00	5444
5052	" " $35 Potato Manure	......	0.22	2.81	3.03	2.46	3.00	4.65	3.68	11.33	10.00	7.65	8.00	6.06	7.00	4.28	27.55	....	35.00	5052
5260	" " Lymph Guano	......	0.38	2.75	3.13	3.78	4.46	3.94	2.15	10.55	10.00	8.40	7.00	5.35	4.00	1.50	28.19	....	38.00	5260
5211	" " $25 Bone Manure	......	0.12	2.29	2.41	2.46	2.24	3.80	4.20	10.24	9.00	6.04	7.00	0.55	....	6.83	18.46	....	25.00	5211
5259	" " $30 Cyclone Bone	......	0.14	2.58	2.72	2.46	1.78	3.88	6.14	11.80	10.00	5.66	8.00	3.41	3.00	7.71	22.39	....	28.50	5259

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.	BRAND.	MANUFACTURER.	SAMPLED BY.	Station Number.
5258	Electric Trucker's Joy Guano	The Berg Co., Philadelphia, Pa.	Charles Kraus, Egg Harbor City.	5258
5094	Stockbridge Strawberry and Fruit Manure	Bowker Fertilizer Co., New York City.	Dennis C. Crane, Westfield.	5094
5345	Potato and Truck Manure	" " " " "	G. S. Voorhees, Mine Brook.	5345
5093	Stockbridge Potato Manure	" " " " "	Dennis C. Crane, Westfield.	5093
5212	Fish and Potato, Square Brand	" " " " "	James C. Griscom, Woodbury.	5212
5447	Ammoniated Dissolved Bone	" " " " "	Woodnutt Pettit, Salem.	5447
5474	Hill and Drill	" " " " "	J. J. Mitchell, Troy Hills.	5474
5231	Stockbridge Special Complete	" " " " "	J. H. Denise, Freehold.	5231
5264	Union High-Grade Manure	" " " " "	Charles Kraus, Egg Harbor City.	5264
5343	Sure Crop Bone Phosphate	" " " " "	G. S. Voorhees, Mine Brook.	5343
5384	Top Dressing	" " " " "	James H. Schoonmaker, Richfield.	5384
5472	Stockbridge Corn Manure	" " " " "	J. J. Mitchell, Troy Hills.	5472
5589	Potato and Vegetable Manure	Bradley Fertilizer Co., Boston, Mass.	J. H. Denise, Freehold.	5589
5215	No. 3	Brown & Gilman, Philadelphia, Pa.	James C. Griscom, Woodbury.	5215
5056	Special Potato	" " " "	H. I. Budd, Mount Holly.	5056
5216	10 per cent. Guano	" " " "	James C. Griscom, Woodbury.	5216
5214	No. 2	" " " "	" " "	5214

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.		Nitrogen.					Phosphoric Acid.							Potash.						
												Available.								
		From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Chlorine.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Factory.	Selling Price of 2,000 lbs. at Consumers' Depot.	Station Number.
5258	Berg's Electric Trucker's Joy Guano..	......	0.15	3.11	3.26	4.10	2.62	4.57	4.95	12.14	8.00	7.19	7.00	0.89	3.24	4.53	$23.53	....	$48.00	5258
5094	Bowker's Stock. Strawb'y and Fruit..	0.54	......	2.07	2.61	2.46	7.80	1.54	2.40	11.74	7.00	9.34	6.00	6.66	4.32	0.61	29.18	....	42.00	5094
5345	" Potato and Truck..............	0.77	......	2.31	3.08	2.46	5.14	4.28	3.35	12.77	10.00	9.42	8.00	6.85	4.00	7.37	30.23	.....	40.00	5345
5093	" Stock. Potato Manure........	1.38	......	2.28	3.66	3.28	5.38	3.60	3.02	12.00	8.00	8.98	7.00	6.65	5.00	6.74	31.13	....	43.00	5093
5212	" Fish and Pot., Sq. Brand...	......	0.48	2.44	2.92	2.46	5.40	1.57	4 00	10.97	8.00	6.97	....	4.76	4.00	6.44	25.11	....	25.00	5212
5447	" Ammoniated Diss Bone...	0.71	.....	1.28	1.99	2.05	7.88	0.42	2.25	10.55	10.00	8.30	8.00	3.12	2.00	3.19	21.18	....	31.00	5447
5474	" Hill and Drill....................	1.35	......	0.85	2.20	2.05	6.64	0.94	3.85	11.43	10.00	7.58	8.00	2.46	2.00	2.30	20.77	....	36.00	5474
5231	" Stock. Special Complete....	2.19	......	1.51	3.70	3.28	5.14	2.95	2.95	11.04	....	8.09	7.00	7.24	5.00	7.27	30.30	....	40.00	5231
5264	" Union High-Grade Man.....	1.56	......	2.25	3.81	3.28	2.62	3.77	4.81	11.20	9.00	6.39	8.00	8.77	7.00	8.30	30.84	....	36.00	5264
5343	" Sure Crop Bone Phos.........	0.18	......	0.82	1.00	0.82	5.86	2.83	3.07	11.76	10.00	8.69	8.00	0.93	1.00	2.55	16.80	....	25.00	5343
5384	" Top Dressing.....................	1.87	0.17	3.44	5.48	4.92	4.12	1.66	2.75	8.53	6.00	5.78	3.00	4.98	5.00	5.30	31.52	....	40.00	5384
5472	" Stockbridge Corn Manure..	1.12	0.14	1.82	3.08	3.28	6.20	3.27	2.78	12.25	9.00	9.47	8.00	4.83	4.25	4 98	28.09	....	43.00	5472
5589	Bradley's Potato and Vegetable........	......	1.05	2.58	3.63	3.69	3.12	3.93	4.35	11.40	9.00	7.05	8.00	6.09	6.00	5.90	28.99	....	40.00	5589
5215	Brown & Gilman's No. 3..................	......	0.21	2.39	2.60	2.46	5.64	2.38	3.12	11.14	....	8.02	6.00	3.52	4.00	3.41	23.92	....	33.00	5215
5056	" " Special Potato.....	......	0.72	1.82	2.54	2.46	2.38	5.40	2.61	10.39	....	7.78	6.00	6.33	6.00	6.11	25.67	....	36.00	5056
5216	" " 10 Per ct. Guano..	. ....	4.77	3.79	8.56	8.20	4.08	1.16	1.60	6.84	....	5.24	3.00	3.93	3.00	3.69	40.48	....	55.00	5216
5214	" " No. 2..................	......	2.32	2.18	4.50	3.28	6 14	1.66	1.92	9.72	....	7.80	6.00	6.32	6.00	5.77	32.12	....	40.00	5214

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.	BRAND.	MANUFACTURER.	SAMPLED BY.	Station Number.
5187	Potato Manure	Brown & Gilman, Philadelphia, Pa.	I. W. Nicholson, Camden.	5187
5217	Special Potato Manure	Chemical Co. of Canton, Baltimore, Md.	James C. Griscom, Woodbury.	5217
5267	Baker's Special Wheat, Corn and Grass Mixture	" " " " "	Charles Kraus, Egg Harbor City.	5267
5268	" Berry Guano	" " " " "	" " " "	5268
5218	Trucker's Delight	" " " " "	James C. Griscom, Woodbury.	5218
5301	Baker's Pride of New Jersey	" " " " "	J. H. Richardson, Rio Grande.	5301
5269	Standard High-Grade Guano	" " " " "	Charles Kraus, Egg Harbor City.	5269
5389	Farmers' Reliable, for all Crops	Chicopee Guano Co., New York City.	James H. Schoonmaker, Richfield.	5389
5390	Potato Manure	" " " " "	" " "	5390
5319	King Philip	Clark's Cove Fertilizer Co., New York City.	A. Dilts, Copper Hill.	5319
5235	Defiance	" " " " " "	J. H. Denise, Freehold.	5235
5119	Great Planet A	" " " " " "	H. I. Budd, Mount Holly.	5119
5421	Potato Phosphate	" " ' " " "	J. H. Denise, Freehold.	5421
5234	"A" Brand	" " " " " "	" " "	5234
5120	Unicorn	" " " " " "	H. I. Budd, Mount Holly.	5120
5040	Alkaline Bone Phosphate	E. Frank Coe Co., New York City.	" " " "	5040
5099	Potato Fertilizer	" " " "	Dennis C. Crane, Westfield.	5099

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.		Nitrogen.					Phosphoric Acid.							Potash.		Chlorine.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Factory.	Selling Price of 2,000 lbs. at Consumers' Depot.	Station Number.
		From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Available. Found.	Available. Guaranteed.	Found.	Guaranteed.					
5187	Brown & Gilman's Potato Manure....	......	1 79	1.99	3.78	3.28	6.26	1.37	2.55	10.18	....	7.63	6.00	6.29	6.00	6.03	$29.66	....	$42.00	5187
5217	C. C. C. Special Potato Manure.........	1.29	......	1.22	2.51	2.46	5 94	0.55	0.37	6.86	....	6.49	6.00	8.93	9.00	2.84	25.94	....	37.00	5217
5267	" Baker's Special Wheat, etc...	......	......	0.97	0.97	0.82	4.00	4.54	2.62	11.16	11.00	8.54	9.00	1.68	2.00	4.00	17.06	....	25.00	5267
5268	" " Berry Guano...........	......	1 82	1.57	3.39	3.28	6.66	1.60	1.01	9.27	....	8.26	6.00	2.08	4.00	4.39	24.70	....	33.00	5268
5218	" Trucker's Delight..................	......	0.67	3.75	4.42	4.92	6.52	0.34	0.36	7.22	....	6.86	8.00	3.08	4.00	4.10	27.24	....	37.00	5218
5301	" Baker's Pride of N. J...........	0.14	......	1.69	1.83	1.64	1.00	5.96	1.64	8.60	10.00	6.96	8.00	4.33	2.50	9.52	19.96	....	27.00	5301
5269	" Standard H. G. Guano...........	......	0.35	1.89	2.24	2.05	4.18	3.70	3.18	11.06	11.00	7.88	9.00	2.70	2.50	2.77	21.75	....	32.00	5269
5389	Chicopee Farmers' Rel. for all crops...	0.11	0.90	1.46	2.47	1.64	7.96	0.54	0.10	8.60	10.00	8.50	8.00	1.76	2.00	0.50	21.40	....	35.00	5389
5390	" Potato Manure..................	......	2.07	0.95	3.02	2.87	6.50	1.01	0.74	8.25	9.00	7.51	7.00	5.58	5.00	0.61	26.41	....	40.00	5390
5319	Clark's Cove King Philip.................	......	0.16	1.54	1.70	1.23	1.04	4.79	4.29	10.12	7.00	5.83	6.00	3.42	3.00	3.11	18.31	....	27.00	5319
5235	" " Defiance......................	......	......	1.16	1.16	0.82	3.36	4.28	2.57	10.21	....	7.64	6.00	2.07	1.00	2.91	16.88	....	30.00	5235
5119	" " Great Planet A...........	......	1.14	2.34	3.48	3.49	5.02	2.60	1.52	9.14	8.50	7.62	7.50	7.44	7.50	4.82	29.50	....	40.00	5119
5421	" " Potato Phosphate.......	......	0.23	2.43	2.66	2.46	4.26	2.64	1.62	8.52	....	6.90	6.00	5.09	5.00	7.00	23.49	....	36.00	542[illegible]
5234	" " "A" Brand..................	......	1.00	2.43	3.43	3.28	4.92	2.52	1.48	8.92	....	7.44	5.00	6.78	5.00	4.62	28.42	....	42.00	5234
5120	" " Unicorn......................	......	0.12	1.74	1.86	1.64	4.82	3.63	3.71	12.16	10.00	8.45	8.00	1.86	2.00	2.60	20.64	....	28.00	5120
5040	Coe's Alkaline Bone Phosphate.......	......	0.10	1.35	1.45	1.05	6.66	1.52	4.01	12.19	11.00	8.18	9.00	2.03	1.85	0.42	19.44	....	29.00	5040
5099	" Potato Fertilizer......................	......	0.53	1.42	1.95	2.05	5.60	1.53	2.86	9.99	9.00	7.13	8.00	5.31	6.00	0.68	22.84	....	38.00	5099

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.	BRAND.	MANUFACTURER.	SAMPLED BY.	Station Number.
5237	Excelsior Guano, Blue Brand	E. Frank Coe Co., New York City.	J. H. Denise, Freehold.	5237
5350	Matchless Grain Fertilizer	" " " "	G. S. Voorhees, Mine Brook.	5350
5483	Excelsior Potato Fertilizer	" " " "	J. J. Mitchell, Troy Hills.	5483
5531	Celebrated Special Potato Fertilizer	" " " "	W. O. Ward, Hainesburg.	5531
5097	XXV. Ammoniated Bone Superphosphate	" " " "	Dennis C. Crane, Westfield.	5097
5241	Excelsior Guano, Red Brand	" " " "	J. H. Denise, Freehold.	5241
5481	Excelsior Guano, Gold Brand	" " " "	J. J. Mitchell, Troy Hills.	5481
5238	Peach Tree, Fruit and Grape Vine Fertilizer	" " " "	J. H. Denise, Freehold.	5238
5240	Fish and Potash	" " " "	" " "	5240
5236	High-Grade Ammoniated Bone Superphosphate	" " " "	" " "	5236
5100	Potato, Hop and Tobacco Phosphate	Crocker Fert. and Chem. Co., Buffalo, N. Y.	Dennis C. Crane, Westfield.	5100
5569	Ammoniated Bone Superphosphate	" " " " " "	J. B. Eckerson, River Vale.	5569
5422	Wheat and Corn Phosphate	" " " " " "	J. H. Denise, Freehold.	5422
5479	New Rival Ammoniated Superphosphate	" " " " " "	J. J. Mitchell, Troy Hills.	5479
5385	Vegetable Bone Superphosphate	" " " " " "	James H. Schoonmaker, Richfield.	5385
5377	Special Potato Manure	" " " " " "	G. S. Voorhees, Mine Brook.	5377
5574	Wheat and Corn Brand	L. B. Darling Fertilizer Co., Pawtucket, R. I.	J. B. Eckerson, River Vale.	5574

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.		Nitrogen.					Phosphoric Acid.							Potash.		Chlorine.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Factory.	Selling Price of 2,000 lbs. at Consumers' Depot.	Station Number.
		From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Available. Found.	Available. Guaranteed.	Found.	Guaranteed.					
5237	Coe's Excelsior Guano, Blue Brand...	......	4.47	2.16	6.63	6.56	3.82	1.71	2.98	8.51	7.00	5.53	6.00	4.90	2.50	0.50	$36.39	....	$50.00	5237
5350	" Matchless Grain Fertilizer.......	......	......	0.95	0.95	0.63	8.12	1.62	3.63	13.37	12.00	9.74	11.00	1.48	1.00	0.16	19.04	....	28.00	5350
5483	" Excelsior Potato Fertilizer......	0.48	1.29	1.49	3.26	3.28	4.76	1.67	4.30	10.73	8.00	6.43	7.00	6.35	6.00	0.38	28.07	....	43.00	5483
5098	" Celebrated Special Potato........	......	0.16	1.73	1.89	1.64	6.74	0.98	3.23	10.95	10.00	7.72	9.00	3.45	3.50	0.40	21.61	....	38.00	5098
5097	" XXV. Ammon. Bone Super.....	......	0.13	1.27	1.40	1.03	6.12	2.12	3.78	12.02	9.00	8.24	8.00	1.92	1.00	0.35	19.14	....	26.00	5097
5241	" Excelsior Guano, Red Brand...	......	0.78	2.35	3.13	3.28	8.20	0.68	0.95	9.83	10.00	8.88	9.00	5.62	6.00	1.24	28.66	....	42.00	5241
5481	" " " Gold Brand..	......	0.74	1.59	2.33	2.46	5.88	1.37	3 22	10.47	9.00	7.25	8.00	5.18	6.00	0.60	24.34	....	43.00	5481
5238	" Peach Tree, Fruit, Grape Vine..	......	......	1.20	1.20	1.23	5.96	1.74	3.41	11.11	10.00	7.70	8.00	5.54	5.50	0.52	21.53	....	30.00	5238
5240	" Fish and Potash......................	......	0 12	2.86	2.98	3.28	2.82	3.05	3.56	9.43	....	5.87	6.00	2.37	2.75	5.56	21.61	....	34.00	5240
5236	" H. G. Ammon. Bone Super......	......	0.56	1.57	2.13	2.05	6.78	1.26	3.28	11.32	11.00	8.04	9.00	2.05	1.85	0.48	21.29	....	34.00	5236
5100	Crocker's Potato, Hop and Tobacco..	......	0.22	1.90	2.12	2.05	7.98	1.25	1.60	10.83	11.00	9.23	10.00	3.68	3.20	3.74	23.35	....	38.00	5100
5569	" Amon. Bone Super...........	......	0.14	2.97	3.11	2.87	7.18	1.35	2.26	10.79	11.00	8.53	10.00	1.39	1.08	1.64	24.12	....	38.00	5569
5422	" Wheat and Corn Phos.......	......	0.12	2.09	2.21	2.05	7.40	1.38	1.97	10.75	11.00	8.78	10.00	1.98	1.62	2.31	21.71	....	35.00	5422
5479	" New Rival Ammon. Super.	......	......	1.47	1.47	1.23	6.44	1.88	2.67	10.99	11.00	8.32	10.00	1.88	1.62	1.93	18.72	....	34.00	5479
5385	" Vegetable Bone Super......	0.10	0.17	4 84	5.11	4.92	5.54	0.45	0.57	6.56	7.00	5.99	6.00	7.82	5.94	5.96	32.89	....	40.00	5385
5377	" Special Potato Manure......	......	0.14	3.35	3.49	3.69	6.92	0.57	1.06	8.55	9.00	7.49	8.00	6.73	5.40	6.21	28.45	....	40.00	5377
5574	Darling's Wheat and Corn Brand.....	......	0.13	2.20	2.33	2.05	5.86	3.40	2.60	11.86	9.00	9.26	....	2.87	2.00	0.67	24.20	....	35.00	5574

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.	BRAND.	MANUFACTURER.	SAMPLED BY.	Station Number.
5575	Animal Fertilizer, "G" Brand	L. B. Darling Fertilizer Co., Pawtucket, R. I.	J. B. Eckerson, River Vale.	5575
5101	Potato and Root Crop Manure	" " " " " "	Dennis C. Crane, Westfield.	5101
5392	Potato Manure,	Davidge Fertilizer Co., New York City.	James H. Schoonmaker, Richfield.	5392
5323	Wheat and Corn Compound	" " " " "	A. Dilts, Copper Hill.	5323
5391	Special Favorite for Cereals	" " " " "	James H. Schoonmaker, Richfield.	5391
5594	The Vegetatore	" " " " "	J. M. White, New Brunswick.	5594
5041	Sure Shot Superphosphate	H. W. Doughten, Moorestown, N. J.	H. I. Budd, Mount Holly.	5041
5549	Reaper Brand	Farmers' Fertilizer Co., Syracuse, N. Y.	Dayton N. Warbasse, Huntsburg.	5549
5550	Pomona Brand for Fruit	" " " " "	" " "	5550
5271	Fish and Potash	J. C. Fifield & Sons, Bakersville, N. J.	Charles Kraus, Egg Harbor City.	5271
5513	Complete Phosphate	Fithian & Pennell, Bridgeton, N. J.	Theo. F. D. Baker, Bridgeton.	5513
5243	Irish Potato Manure	Geo. B. Forrester, New York City.	John H. Denise, Freehold.	5243
5303	Pride of Cumberland	Garrison & Minch, Bridgeton, N. J.	J. H. Richardson, Rio Grande.	5303
5508	Pride Fish Guano	" " " "	Theo. F. D. Baker, Bridgeton.	5508
5305	Our Double X Pride	" " " "	J. H. Richardson, Rio Grande.	5305
5511	Bay Side	" " " "	Theo. F. D. Baker, Bridgeton.	5511
5304	Trucker's Pride	" " " "	J. H. Richardson, Rio Grande.	5304

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.		Nitrogen.					Phosphoric Acid.					Available.		Potash.		Chlorine.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Factory.	Selling Price of 2,000 lbs. at Consumers' Depot.	Station Number.
		From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.					
5575	Darling's Animal Fertilizer, "G" Brand..	......	0.14	1.92	2.06	2.05	5.26	3.40	2.64	11.30	7.00	8.66	....	3.96	4.00	6.48	$23.08	......	$31.00	5575
5101	" Potato and Root Crop..............	......	0.23	2.65	2.88	2.87	4.36	3.80	2.76	10.92	10.00	8.16	....	7.33	7.00	7.40	28.37	......	40.00	5101
5392	Davidge's Potato Manure...	......	1.69	1.68	3.37	2.87	5.52	1.24	1.98	8.74	10.00	6.76	9.00	4.66	4.00	0.50	26.20	......	41.00	5392
5323	" Wheat and Corn Compound...	......	0.32	0.72	1.04	0.82	0.62	5.46	3.90	9.98	8.00	6.08	7.00	1.30	1.00	0.36	14.41	......	26.00	5323
5391	" Special Favorite for Cereals...	......	0.79	1.12	1.91	1.23	1.94	3.75	3.68	9.37	11.00	5.69	10.00	3.18	1.50	0.37	18.88	......	36.00	5391
5594	" The Vegetatore.........................	......	1.43	1.53	2.96	2.87	2.84	1.94	1.93	6.71	....	4.78	5.00	4.98	4.00	0.50	22.54	......	33.00	5594
5041	Doughten's Sure Shot Superphosphate...	......	0.60	2.21	2.81	2.87	8.10	1.74	1.26	11.10	11.00	9.84	10.00	3.30	3.00	3.31	26.04	......	30.00	5041
5549	Farmer's Reaper Brand	......	0.14	1.16	1.30	1.64	3.26	.2.07	1.20	6.53	7.50	5.33	5.00	4.24	4.32	14.86	15.77	......	35.00	5549
5550	" Pomona Brand, for Fruit.........	......	0.45	0.46	0.91	1.23	2.56	3.10	1.25	6.91	7.00	5.66	....	3.98	4.32	11.83	14.58	......	34.00	5550
5271	Fifield's Fish and Potash.........................	......	......	2.67	2.67	2.46	2.60	1.54	1.44	5.58	2.40	4.14	2.00	4.32	2.00	13.46	19.20	......	30.00	5271
5513	Fithian & Pennell's Complete Phos........	0.87	......	1.00	1.87	1.64	7.00	1.41	3.06	11.47	....	8.41	8.00	2.15	2.00	1.94	20.29	......	25.00	5513
5243	Forrester's Irish Potato Manure..............	1.44	1.85	0.32	3.61	3.69	7.00	0.39	0.07	7.46	....	7.39	5.50	9.26	10.00	2.46	31.30	......	40.50	5243
5303	Garrison & Minch's Pride of Cumberland	0.42	0 11	1.22	1.75	1.64	4.04	2.96	6.06	13.06	9.00	7.00	8.00	2.48	2.50	6.47	19.69	......	27.00	5303
5508	" " Pride Fish Guano.....	0.36	0.96	2.15	3.47	4.10	5.58	1.73	2.85	10.16	8.00	7.31	....	5.82	7.00	4.58	27.79	......	35.00	5508
5305	" " Our Double X Pride..	......	......	1.13	1.13	1.23	3.16	3.21	3.45	9.82	8.00	6.37	7.00	2.50	2.50	6.77	15.87	......	23.00	5305
5511	" " Bay Side.....................	0.10	0 20	1.44	1.74	1.64	4.92	2.48	2.40	9.80	8.00	7.40	....	2.87	2.00	7.46	19.19	.....	24.00	5511
5304	" " Trucker's Pride........	0.98	2.04	1.48	4.50	4.10	4.64	1.63	2.10	8.37	6.00	6.27	....	6.93	7.00	7.56	30.39	......	37.00	5304

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.	BRAND.	MANUFACTURER.	SAMPLED BY.	Station Number.
5510	Our Pride Peach Grower	Garrison & Minch, Bridgeton, N. J.	Theo. F. D. Baker, Bridgeton.	5510
5272	Oak Island Fertilizer	Theodore Glazer, Linden, N. J.	Charles Kraus, Egg Harbor City.	5272
5371	General, for Grain and Grass	Great Eastern Fertilizer Co., Rutland, Vt.	G. S. Voorhees, Mine Brook.	5371
5576	Vegetable, Vine and Tobacco	" " " " " "	J. B. Eckerson, River Vale.	5576
5369	Oats, Buckwheat and Seeding-Down Phosphate	" " " " " "	G. S. Voorhees, Mine Brook.	5369
5370	Garden Special	" " " " " "	" " " "	5370
5577	Metropolitan	H. B. Griffing's Sons & Co., New York City.	" " " "	5577
5191	Complete Manure	Hassinger Fertilizer Co., Philadelphia, Pa.	I. W. Nicholson, Camden.	5191
5376	Keystone Dissolved Bone Phosphate	S. M. Hess & Bro., Reading, Pa.	G. S. Voorhees, Mine Brook.	5376
5042	Fish and Potash	" " " " "	H. I. Budd, Mount Holly.	5042
5423	Potato and Truck Manure	" " " " "	J. H. Denise, Freehold.	5423
5324	Ammoniated Bone Superphosphate	" " " " "	A. Dilts, Copper Hill.	5324
5326	Corn and Potato Manure	Wm. Hill, Copper Hill, N. J.	" " "	5326
5327	Pure Bone Phosphate	" " " " "	" " "	5327
5532	Potato Manure	T. P. Hopler & Co., Belvidere, N. J.	Wm. O. Ward, Hainesburg.	5532
5533	Corn Manure	" " " " "	" " "	5533
5424	Ammoniated Bone Superphosphate	S. H. Howitz, Philadelphia, Pa.	J. H. Denise, Freehold.	5424

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.		Nitrogen.					Phosphoric Acid.							Potash.		Chlorine.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Factory.	Selling Price of 2,000 lbs. at Consumers' Depot.	Station Number.
		From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Available. Found.	Available. Guaranteed.	Found.	Guaranteed.					
5510	Garrison & Minch's Our Pride Peach Gr'w'r	......	.....	0.75	0.75	0.82	4.14	2.39	3.67	10.20	10.00	6.53	....	7.26	8.00	12.04	$19.12	....	$23.00	5510
5272	Glazer's Oak Island Fertilizer....................	......	0.61	2.37	2.98	2.46	1.22	1.13	0.68	3.03	8.00	2.35	5.00	4.03	3.50	0.71	17.95	....	28.00	5272
5371	Great East'n General for Grain and Grass..	0.50	......	2.06	2.56	2.46	6.34	1.54	1.25	9.13	9.00	7.88	8.00	2.61	2.00	5.69	21.85	....	32.00	5371
5576	" " Vegetable, Vine and Tobac...	......	......	2.26	2.26	2.05	6.64	1.70	1.20	9.54	9.00	8.34	8.00	3.08	3.24	6.86	22.00	....	28.00	5576
5369	" " Oats, Buckwheat, etc...........	0.12	0.10	1.06	1.28	0.82	5.60	2.26	1.65	9.51	9.00	7.86	8.00	3.90	4.00	3.83	18.81	....	30.00	5369
5370	" " Garden Special.....................	0.15	0.14	3.02	3.31	3.28	4.30	1.86	2.19	8.35	....	6.16	6.00	8.12	9.00	8.27	27.72	....	40.00	5370
5577	Griffing's Metropolitan	......	0.22	1.74	1.96	0.82	1.26	1.99	2.60	5.85	3.50	3.25	....	1.14	1.00	11.28	13.14	....	30.00	5577
5191	Hassinger's Complete Manure.....................	......	......	1.89	1.89	1.64	5.52	1.93	4.57	12.02	11.00	7.45	....	3.97	4.00	3.80	21.71	....	33.00	5191
5376	Hess's Keystone Diss. Bone Phosphate......	0.11	0.10	0.84	1.05	0.82	6.06	2.09	2.55	10.70	10.00	8.15	8.00	1.52	1.00	2.05	16.61	....	28.00	5376
5042	" Fish and Potash..............................	......	0.11	1.68	1.79	1.64	7.14	1.68	1.35	10.17	....	8.82	7.00	4.31	4.00	4.38	22.13	....	30.00	5042
5423	" Potato and Truck Manure..............	......	0.17	1.95	2.12	1.64	5.08	4.14	1.03	10.25	....	9.22	8.00	4.91	6.00	5.21	24.22	....	38.00	5423
5324	" Ammon. Bone Superphosphate	0.41	0.27	1.39	2.07	1.64	5.68	1.77	3.20	10.65	9.00	7.45	8.00	1.76	2.00	2.49	19.60	....	30.00	5324
5326	Hill's Corn and Potato Manure...................	......	0 56	2.06	2.62	2.05	2.42	4.92	1.81	9.15	10.00	7.34	....	5.59	5.00	7.31	24.41	....	30.00	5326
5327	" Pure Bone Phosphate........................	......	0.22	1.78	2.00	2.05	2.94	4.01	1.65	8.63	10.00	6.98	....	4.29	2.50	8.78	20.57	....	27.00	5327
5532	Hopler's Potato Manure............................	0.28	......	0.53	0.81	3.00	8.80	1.14	0.62	10.56	....	9.94	11.00	5.45	9.00	8.14	20.81	....	35.00	5532
5533	" Corn Manure..................................	0.18	0.36	0.41	0.95	3.00	1.72	3.15	1.00	5.87	....	4.87	7.00	3.87	4.00	11.41	13.44	....	28.00	5533
5424	Howitz's Ammon. Bone Superphosphate...	......	......	2.02	2.02	1.85	5.83	1.92	3.41	11.21	10.00	7.80	9.00	2.75	2.00	5.08	21.05	....	35.00	5424

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.	BRAND.	MANUFACTURER.	SAMPLED BY.	Station Number.
5425	Potato Fertilizer	S. H. Howitz, Philadelphia, Pa.	J. H. Denise, Freehold.	5425
5587	Imperial Guano	Imperial Guano Co., Norfolk, Va.	Station.	5587
5588	Potato Fertilizer	L. D. Jones, Red Bank, N. J.	J. H. Denise, Freehold.	5588
5329	High-Grade Manure	Kuhl & Johnson, Flemington, N. J.	A. Dilts, Copper Hill.	5329
5330	Complete Phosphate	" " " "	" "	5330
5057	Special Potato and Truck	E. J. Lampson, Bordentown, N. J.	H. I. Budd, Mount Holly.	5057
5449	Farmers' Bone Phosphate	Lewis & Co., Smyrna, Del.	Woodnutt Pettit, Salem.	5449
5221	Ammoniated Dissolved Bone Phosphate	Lister's A. C. Works, Newark, N. J.	James C. Griscom, Woodbury.	5221
5579	Standard Pure Bone Superhosphate	" " " " "	J. B. Eckerson, River Vale.	5579
5121	Standard Fertilizer "Success"	" " " " "	H. I. Budd, Mount Holly.	5121
5451	Harvest Queen Phosphate	" " " " "	Woodnutt Pettit, Salem.	5451
5485	Standard Fertilizer, U. S. Phosphate	" " " " "	J. J. Mitchell, Troy Hills.	5485
5396	Lawn Fertilizer	" " " " "	J. H. Schoonmaker, Richfield.	5396
5401	Celebrated Corn Manure	" " " " "	" " "	5401
5353	Corn Fertilizer, No. 2	" " " " "	G. S. Voorhees, Mine Brook.	5353
5581	Potato Manure	" " " " "	J. B. Eckerson, River Vale.	5581
5399	Vegetable Compound	" " " " "	James H. Schoonmaker, Richfield.	5399

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.		Nitrogen.					Phosphoric Acid.							Potash.		Chlorine.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Factory.	Selling Price of 2,000 lbs. at Consumers' Depot.	Station Number.
		From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Available. Found.	Available. Guaranteed.	Found.	Guaranteed.					
5425	Howitz's Potato Fertilizer	......	......	0.96	0.96	0.82	5.22	0.81	1.82	7.85	....	6.03	6.00	4.57	4.86	7.45	$16.04	....	$35.00	5425
5587	Imperial Guano	0.17	1.74	2.66	4.57	4.92	5.32	1.54	2.11	8.97	....	6.86	7.00	10.55	10.00	8.64	35.02	....	42.50	5587
5588	Jones's Potato Fertilizer	......	0.18	0.60	0.78	3.28	2.24	3.30	3.66	9.20	10.00	5.54	....	3.55	3.00	7.63	14.57	....	40.00	5588
5329	Kuhl & Johnson's H. G. Manure	0.88	......	2.56	3.44	3.28	5.88	1.79	2.90	10.57	9.00	7.67	7.00	8.38	7.00	8.41	30.36	....	40.00	5329
5330	" " Complete Phos	1.08	......	1.78	2.86	2.46	8.04	1.28	2.68	12.00	11.00	9.32	10.00	2.37	2.00	2.33	24.89	....	34.00	5330
5057	Lampson's Special Potato and Truck	......	0.14	1.67	1.81	2.46	7.78	1.20	1.52	10.50	....	8.98	8.00	5.10	6.00	5.44	23.20	....	42.00	5057
5449	Lewis's Farmers' Bone Phosphate	0.21	0.33	0.46	1.00	1.23	7.06	1.50	1.67	10.23	9.00	8.56	8.00	2.75	2.50	5.35	17.66	....	28.00	5449
5221	Lister's Ammon. Diss. Bone Phos	......	0.30	1.58	1.88	1.00	5.50	3.25	2.82	11.57	11.00	8.75	9.00	1.70	1.50	1.75	20.59	....	32.00	5221
5579	" Standard Pure Bone Super	....	0.39	2.01	2.40	2.34	8.68	1.48	2.03	12.19	12.00	10.16	10.00	1.60	1.50	1.63	23.82	....	34.00	5579
5121	" Standard Fert, "Success"	......	0.47	1.20	1.67	1.03	5.42	3.34	4.37	13.13	....	8.76	9.50	1.93	1.50	1.97	20.68	....	26.00	5121
5451	" Harvest Queen Phosphate	......	0.24	1.33	1.57	1.03	5.54	3.53	3.25	12.32	....	9.07	9.50	1.44	1.50	1.52	19.87	....	28.00	5451
5485	" Standard Fert., U. S. Phos	......	0.35	1.06	1.41	1.31	3.06	4.01	2.06	9.13	8.00	7.07	7.00	1.82	2.00	0.40	16.81	....	24.50	5485
5396	" Lawn Fertilizer	......	......	1.13	1.13	1.64	6.24	1.08	0.44	7.76	....	7.32	7.00	2.85	3.50	0.55	16.64	....	26.50	5396
5401	" Celebrated Corn Manure	......	1.65	1.65	3.30	3.69	5.38	2.07	1.18	8.63	....	7.45	7.50	7.58	7.00	7.16	28.36	....	39.00	5401
5353	" Corn Fertilizer, No. 2	......	0.37	1.72	2.09	1.80	9.56	0.92	1.22	11.70	9.25	10.48	....	3.99	4.00	3.92	24.99	....	32.00	5353
5581	" Potato Manure	......	2.30	1.46	3.76	3.69	5.74	1.86	1.13	8.73	....	7.60	7.50	7.52	7.00	7.12	30.03	....	41.00	5581
5399	" Vegetable Compound	......	1.16	2.65	3.81	3.69	4.44	2.01	1.38	7.83	....	6.45	7.75	6.82	7.00	5.62	28.29	....	39.00	5399

Complete Fertilizers

Furnishiug Nitrogen, Phosphoric Acid and Potash.

Station Number.	BRAND.	MANUFACTURER.	SAMPLED BY.	Station Number.
5122	Potato Fertilizer, No. 2	Lister's A. C. Works, Newark, N. J.	H. I. Budd, Mount Holly.	5122
5306	Champion Fertilizer	Lord & Polk, Odessa, Delaware.	J. H. Richardson, Rio Grande.	5306
5427	Cecrops Brand	Frederick Ludlam, New York City.	J. H. Denise, Freehold.	5427
5276	Economical Manure	The Mapes F. & P. Guano Co., New York.	Chas. Kraus, Egg Harbor City.	5276
5104	Complete Manure for Heavy Soils	" " " " "	Dennis C. Crane, Westfield.	5104
5275	Complete Manure for Light Soils	" " " " "	Chas. Kraus, Egg Harbor City.	5275
5197	Fruit and Vine Manure	" " " " "	I. W. Nicholson, Camden.	5197
5198	Cabbage and Cauliflower Manure	" " " " "	" " "	5198
5359	Complete Manure for General Use	" " " " "	G. S. Voorhees, Mine Brook.	5359
5357	Nitrogenized Superphosphate	" " " " "	" " " "	5357
5535	Ammoniated Dissolved Bone with Potash	" " " " "	W. O. Ward, Hainesburg.	5535
5490	XXV. Brand	" " " " "	J. J. Mitchell, Troy Hills.	5490
5199	Dried and Ground Fish	" " " " "	I. W. Nicholson, Camden.	5199
5403	Potato Manure	" " " " "	James H. Schoonmaker, Richfield.	5403
5583	Grass and Grain Spring Top-Dressing	" " " " "	J. B. Eckerson, River Vale.	5583
5192	Corn Manure	" " " " "	I. W. Nicholson, Camden.	5192
5043	"A" Brand	" " " " "	H. I. Budd, Mount Holly.	5043

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.		Nitrogen.					Phosphoric Acid.							Potash.		Chlorine.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Factory.	Selling Price of 2,000 lbs. at Consumers' Depot.	Station Number.
		From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Available. Found.	Available. Guaranteed.	Found.	Guaranteed.					
5122	Lister's Potato Fertilizer, No. 2........	......	0.23	1.83	2.06	1.80	5.46	3.97	1.64	11.07	9.25	9.43	....	3.81	4.00	3.37	$23.54	....	$35.00	5122
5306	Lord & Polk's Champion Fertilizer...	0.35	0.13	1.53	2.01	1.23	5.42	1.56	3.37	10.35	9.00	6.98	7.00	2.27	2.00	3.95	19.36	....	27.00	5306
5427	Ludlam's Cecrops Brand..................	1.38	......	1.97	3.35	3.28	4.16	2.63	3.97	10.76	....	6.79	7.00	6.79	7.00	6.49	27.71	....	40.00	5427
5276	Mapes' Economical Manure.............	0.28	0.41	1.49	2.18	2.46	4.48	1.65	1.95	8.08	8.00	6.13	6.00	10.02	8.00	9.14	25.25	....	39.00	5276
5104	" Com. Man. for Heavy Soils...	1.10	1.51	2.51	5.12	4.92	6.84	2.52	2.17	11.53	10.00	9.36	8.00	4.36	3.00	0.59	35.01	....	40.00	5104
5275	" " " " Light Soils.....	0.65	1.71	2.55	4.91	4.92	7.00	2.52	1.58	11.10	8.00	9.52	6.00	4.36	6.00	4.13	33.69	....	46.00	5275
5197	" Fruit and Vine Manure.......	0.41	0.67	1.65	2.73	1.64	3.10	4.17	2.44	9.71	7.00	7.27	5.00	11.08	10.00	0.88	31.71	....	40.00	5197
5198	" Cabbage and Cauliflower......	1.37	1.23	1.99	4.59	4.10	3.70	2.54	1.87	8.11	6.00	6.24	6.00	6.47	6.00	6.19	30.08	....	40.00	5198
5359	" Complete Man. for Gen. Use..	0.61	0.80	2.04	3.45	3.28	6.24	2.82	2.69	11.75	10.00	9.06	8.00	4.16	4.00	4.00	28.35	....	40.00	5359
5357	" Nitrogenized Superphos........	0.40	0.68	1.62	2.70	2.05	7.14	3.73	1.33	12.20	11.00	10.87	9.00	3.24	2.50	3.05	26.80	....	32.00	5357
5535	" Am. Diss. Bone with Potash..	0.10	0.20	1.68	1.98	1.23	8.68	3.10	2.46	14.24	12.00	11.78	10.00	1.84	1.50	1.46	24.82	....	30.00	5535
5490	" XXV. Brand........................	0.48	......	1.70	2.18	2.05	5.44	3.43	0.78	9.65	8.00	8.87	7.00	1.26	1.00	2.85	20.41	....	27.00	5490
5199	" Dried and Ground Fish	......	0.39	4.31	4.70	4.10	0.56	3.16	5.50	9.22	6.00	3.72	....	3.45	3.00	6.04	26.57	....	37.00	5199
5403	" Potato Manure.........	0.97	0.63	2.29	3.89	3.69	6.94	0.99	2.21	10.14	8.00	7.93	8.00	7.35	6.00	0.74	32.25	....	42.00	5403
5583	" Gr. and Gr. Spring Top-Dress..	1.28	1.50	2.11	4.89	4.10	5.88	1.73	0.72	8.33	7.00	7.61	5.00	6.13	5.00	5.95	32.16	....	39.00	5583
5192	" Corn Manure........................	0.74	0.70	2.73	4.17	3.69	2.66	6.03	4.05	12.74	10.00	8.69	8.00	4.44	6.00	4.24	31.15	....	41.00	5192
5043	" "A" Brand	0.17	0.55	2.34	3.06	2.46	9.02	3.51	1.51	14.04	12.00	12.53	10.00	1.95	2.50	2.02	29.24	....	37.50	5043

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.	BRAND.	MANUFACTURER.	SAMPLED BY.	Station Number.
5410	Buffalo Fertilizer	Milsom Rendg. and Fert. Co., Buffalo, N. Y.	James H. Schoonmaker, Richfield.	5410
5409	Potato, Hop and Tobacco Phosphate	" " " " " " "	" " "	5409
5515	Complete Phosphate	Jos. A. Minch & Son, Bridgeton, N. J.	Theo. F. D. Baker, Bridgeton.	5515
5516	Bone Phosphate	" " " " "	" " " "	5516
5514	Truck Guano	" " " " "	" " " "	5514
5517	Special Potato Manure	" " " " "	" " " "	5517
5106	Vegetable Fertilizer	Mitchell Fertilizer Works, Tremley, N. J.	Dennis C. Crane, Westfield.	5106
5105	Berry Manure	" " " " "	" " "	5105
5107	Potato Manure	" " " " "	" " "	5107
5603	Harvest Queen Phosphate	Newark Chemical Works, Newark, N. J.	Franklin Dye, Trenton.	5603
5602	Standard Pure Bone Superphosphate	" " " " "	" " "	5602
5335	Ammoniated Dissolved Bone Phosphate	" " " " "	A. Dilts, Copper Hill.	5335
5336	Corn and Potato Phosphate	" " " " "	" " "	5336
5601	Harmony Phosphate	" " " " "	Franklin Dye, Trenton.	5601
5361	Poudrette	Newark Poudrette Co., Newark, N. J.	G. S. Voorhees, Mine Brook.	5361
5623	Newark Fertilizer	Newark Fertilizer Co., Newark, N. J.	J. V. D. Pumyea, Plainville.	5623
5046	Menhaden Fish Guano	James E. Otis, Tuckerton, N. J.	H. I. Budd, Mount Holly.	5046

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.		Nitrogen.					Phosphoric Acid.							Potash.		Chlorine.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Factory.	Selling Price of 2,000 lbs. at Consumers' Depot.	Station Number.
		From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Available. Found.	Available. Guaranteed.	Found.	Guaranteed.					
5410	Milsom's Buffalo Fertilizer	......	0.41	1.87	2.28	2.46	6.20	2.13	3.59	11.92	10.00	8.33	8.00	1.00	1.50	1.05	$21.11	....	$35.00	5410
5409	" Potato, Hop and Tobacco	......	0.18	1.88	2.06	2.46	6.34	1.21	3.87	11.42	9.00	7.55	8.00	2.92	5.00	2.78	21.18	....	35.00	5409
5515	Minch's Complete Phosphate	1.01	......	0.93	1.94	2.05	7.88	0.52	2.08	10.48	....	8.40	9.00	2.44	2.50	2.16	20.34	....	25.00	5515
5516	" Bone Phosphate	......	0.33	2.04	2.37	2.05	1.22	4.40	5.04	10.66	....	5.62	9.00	2.45	2.50	2.92	19.80	....	25.00	5516
5514	" Truck Guano	2.39	......	1.63	4.02	3.69	6.26	0.88	2.16	9.30	....	7.14	7.00	5.19	5.00	4.79	27.93	....	36.00	5514
5517	" Special Potato Manure	1.04	......	0.73	1.77	1.85	6.60	0.45	2.53	9.58	....	7.05	7.00	8.15	8.00	7.83	23.30	....	32.00	5517
5106	Mitchell's Vegetable Fertilizer	1.11	......	2.27	3.38	2.46	5.34	1.36	1.16	7.86	....	6.70	8.00	5.84	5.00	0.64	26.82	....	37.00	5106
5105	" Berry Manure	1.17	......	2.05	3.22	2.46	5.86	1.43	1.17	8.46	10.00	7.29	9.00	5.09	3.78	0.52	26.22	....	37.00	5105
5107	" Potato Manure	1.34	......	2.21	3.55	3.28	5.96	0.91	1.06	7.93	10.00	6.87	9.00	5.39	7.00	0.62	27.01	....	40.00	5107
5603	Newark C. W.'s Harvest Queen	......	0.11	1.00	1.11	1.03	7.32	1.94	2.42	11.68	11.50	9.26	10.00	2.29	2.50	0.25	19.34	....	25.00	5603
5602	" " Stand. P. B. Super	......	0.14	1.94	2.08	2.34	8.18	1.46	2.92	12.56	11.50	9.64	10.00	2.55	2.50	0.33	23.69	....	33.00	5602
5335	" " Am. Dis. Bone Phos.	......	0.18	1.65	1.83	2.46	6.46	1.73	2.70	10.89	12.00	8.19	11.00	2.12	2.00	0.31	20.37	....	28.50	5335
5336	" " C. and P. Phosphate.	......	0.17	1.60	1.77	4.10	4.96	2.22	3.25	10.43	10.00	7.18	9.00	2.26	6.00	0.45	19.19	....	35.00	5336
5601	" " Harmony Phos.	......	0.11	1.00	1.11	1.64	7.72	1.66	2.35	11.73	13.00	9.38	10.00	2.23	2.50	0.18	19.42	....	23.00	5601
5361	" Poudrette	......	0.41	0.99	1.40	....	0.60	1.69	0.57	2.86	....	2.29	....	0.40	....	0.29	8.43	....	16.00	5361
5623	" Fertilizer	......	......	0.62	0.62	....	0.06	1.02	0.42	1.50	....	1.08	....	0.19	....	0.20	3.92	....	15.00	5623
5046	Otis's Menhaden Fish Guano	......	......	3.61	3.61	3.28	2.68	2.49	2.49	7.66	9.00	5.17	....	5.98	5.00	13.62	25.74	....	31.00	5046

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.	BRAND.	MANUFACTURER.	SAMPLED BY.	Station Number.
5222	High-Grade Special Potato	Parker & Co., Mullica Hill, N. J.	James C. Griscom, Woodbury.	5222
5453	Special Potato Manure	Moro Phillips Chemical Co., Philadelphia, Pa.	Woodnutt Pettit, Salem.	5453
5454	Genuine Improved Superphosphate of Lime	" " " " " "	" " "	5454
5555	Tobacco Fertilizer	Preston Fertilizer Co., Greenpoint, L. I.	Dayton N. Warbasse, Huntsburg.	5555
5493	Ammoniated Bone Superphosphate, No. 2	" " " " "	J. J. Mitchell, Troy Hills.	5493
5537	Potato Fertilizer	" " " " "	W. O. Ward, Hainesburg.	5537
5412	Corn Fertilizer	" " " " "	James H. Schoonmaker, Richfield.	5412
5245	Ammoniated Bone Superphosphate	" " " " "	J. H. Denise, Freehold.	5245
5559	Climax Phosphate	The Quinnipiac Co., New York City.	Dayton N. Warbasse, Huntsburg.	5559
5560	Potato Manure	" " " " "	" " "	5560
5338	High-Grade Farmers' Friend	Read Fertilizer Co., Syracuse, N. Y.	A. Dilts, Copper Hill.	5338
5337	Blood and Bone Fertilizer	" " " " "	" " "	5337
5123	Fish Guano	Edward Rigg, Burlington, N. J.	H. I. Budd, Mount Holly.	5123
5428	Sure Growth Compound	Scott Fertilizer Co., Elkton, Md.	J. H. Denise, Freehold.	5428
5459	Tomato Fertilizer	" " " " "	Woodnutt Pettit, Salem.	5459
5134	Standard Fertilizer	Shanley & Van Brunt, Philadelphia, Pa.	H. I. Budd, Mount Holly.	5134
5130	Slaughter-House Fertilizer	" " " "	" " " "	5130

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.		Nitrogen. From Nitrates.	Nitrogen. From Ammonia Salts.	Nitrogen. From Organic Matter.	Nitrogen. Total Found.	Nitrogen. Total Guaranteed.	Phosphoric Acid. Soluble in Water.	Phosphoric Acid. Soluble in Ammonium Citrate.	Phosphoric Acid. Insoluble.	Phosphoric Acid. Total Found.	Phosphoric Acid. Total Guaranteed.	Phosphoric Acid. Available. Found.	Phosphoric Acid. Available. Guaranteed.	Potash. Found.	Potash. Guaranteed.	Chlorine.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Factory.	Selling Price of 2,000 lbs. at Consumers' Depot.	Station Number.
5222	Parker's High-Grade Special Potato..........	0.74	......	1.84	2.58	2.46	6.54	1.27	1.88	9.69	9.00	7.81	7.00	7.75	7.00	7.43	$26.61	....	$29.00	5222
5453	Phillips's Potato Manure, No. 2.................	0.54	......	0.77	1.31	1.85	7.28	2.08	2.36	11.72	....	9.36	9.00	3.17	4.75	3.00	20.32	....	27.00	5453
5454	" Genuine Improved Superphos...	0.61	0.11	1.03	1.75	1.64	6.20	1.44	2.73	10.37	....	7.64	9.50	2.56	2.25	1.45	19.33	....	27.00	5454
5555	Preston's Tobacco Fertilizer........................	......	0.20	6.97	7.17	6.56	1.80	1.50	1.48	4.78	4.50	3.30	....	4.33	10.80	1.73	34.27	....	45.00	5555
5493	" Ammon. Bone Super., No. 2........	......	......	1.49	1.49	1.45	9.30	1.49	1.59	12.38	....	10.79	10.00	2.56	1.75	0.44	22.59	....	30.00	5493
5537	" Potato Fertilizer..........................	......	1.79	2.16	3.95	3.28	4.60	1.48	1.44	7.52	....	6.08	8.00	6.78	7.00	2.43	28.95	....	33.00	5537
5412	" Corn Fertilizer	......	1.70	1.71	3.41	4.10	8.02	1.04	1.20	10.26	....	9.06	9.00	5.28	6.00	2.68	29.13	....	41.00	5412
5245	" Amon. Bone Superphosphate......	......	0.31	2.64	2.95	2.46	3.26	4.59	3.00	10.85	....	7.85	9.00	4.08	2.00	2.34	25.57	....	30.50	5245
5559	Quinnipiac Climax Phosphate.................	......	0.16	1.28	1.44	1.45	0.78	4.93	6.52	12.23	9.00	5.71	8.00	2.12	2.00	2.76	16.96	....	28.60	5559
5560	" Potato Manure.........................	......	0.14	2.34	2.48	2.46	0.20	5.85	4.17	10.22	7.00	6.05	6.00	5.54	5.00	5.30	23.20	....	35.00	5560
5338	Read's High-Grade Farmers' Friend	0.33	0.14	3.39	3.86	3.28	2.36	2.14	2.26	6.76	6.00	4.55	5.00	9.44	10.00	9.71	28.62	....	36.00	5338
5337	" Blood and Bone Fertilizer.............	......	......	1.19	1.19	0.82	1.40	4.46	2.94	8.80	....	5.86	7.00	1.76	1.00	3.95	14.55	....	26.00	5337
5123	Rigg's Fish Guano..	......	0.16	2.73	2.89	2.46	6.06	1.03	1.86	8.95	....	7.09	7.00	3.57	5.00	3.87	23.27	....	33.00	5123
5428	Scott's Sure Growth Compound................	......	0.77	2.68	3.45	3.69	7.30	2.18	2.02	11.50	....	9.48	8.00	7.24	7.00	7.17	31.65	....	37.00	5428
5459	" Tomato Fertilizer..........................	......	2.02	0.53	2.55	2.87	4.18	4 77	6.79	15.74	....	8.95	9.00	6.25	7.00	0.73	29.76	....	35.00	5459
5134	Shanley & Van Brunt's Standard Fert	......	0.72	0.88	1.60	2.46	4.22	0.82	5.54	10.58	8.00	5.04	6.00	2.76	2.00	2.54	16.79	....	35.00	5134
5130	" " Sl'ter-House Fert..	......	0.10	0.92	1.02	1.64	3.74	1.24	6.18	11.16	8.00	4.98	6.00	2.77	2.00	2.64	14.99	....	28.00	5130

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.	BRAND.	MANUFACTURER.	SAMPLED BY.	Station Number.
5131	Extra Early Trucker	Shanley & Van Brunt, Philadelphia, Pa.	H. I. Budd, Mount Holly.	5131
5132	Potato Guano	" " " "	" " " "	5132
5133	All Crop Fertilizer	" " " "	" " " "	5133
5202	No. 1 Bone Phosphate	Sharpless & Carpenter, Philadelphia, Pa.	I. W. Nicholson, Camden.	5202
5308	Soluble Tampico Guano	" " " "	J. H. Richardson, Rio Grande.	5308
5201	Gilt-Edged Potato Manure	" " " "	I. W. Nicholson, Camden.	5201
5439	Seven Per Cent. Potato Guano	" " " "	Geo. A. MacBean, Lakewood.	5439
5224	Swift-Sure Superphosphate	M. L. Shoemaker & Co., Philadelphia, Pa.	James C. Griscom, Woodbury.	5224
5415	Swift-Sure for Potatoes	" " " " "	J. H. Schoonmaker, Richfield.	5415
5124	Potato Fertilizer	John I. Smith, Trenton, N. J.	H. I. Budd, Mount Holly.	5124
5059	Bone Phosphate	" " " "	" " " "	5059
5058	Special Potato	" " " "	" " " "	5058
5540	Ammoniated Bone Phosphate	Susquehanna Fert. Co., Baltimore, Md.	W. O. Ward, Hainesburg.	5540
5283	Peach Tree Formula	The Taylor Provision Co., Trenton, N. J.	Charles Kraus, Egg Harbor City.	5283
5250	Potato, Truck and Tobacco	" " " " " "	J. H. Denise, Freehold.	5250
5282	Special Potato Fertilizer	" " " " " "	Charles Kraus, Egg Harbor City.	5282
5458	High-Grade Corn and Truck Manure	" " " " " "	Woodnutt Pettit, Salem.	5458

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.		Nitrogen. From Nitrates.	Nitrogen. From Ammonia Salts.	Nitrogen. From Organic Matter.	Nitrogen. Total Found.	Nitrogen. Total Guaranteed.	Phosphoric Acid. Soluble in Water.	Phosphoric Acid. Soluble in Ammonium Citrate.	Phosphoric Acid. Insoluble.	Phosphoric Acid. Total Found.	Phosphoric Acid. Total Guaranteed.	Phosphoric Acid. Available. Found.	Phosphoric Acid. Available. Guaranteed.	Potash. Found.	Potash. Guaranteed.	Chlorine.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Factory.	Selling Price of 2,000 lbs. at Consumers' Depot.	Station Number.
5131	Shanley & Van Brunt's Ex. Early T'k'r	......	2.41	0.99	3.40	2.12	4.00	0.93	4.71	9.64	8.00	4.93	6.00	2.55	8.00	2.39	$22.25	....	$40.00	5131
5132	" " Potato Guano..	......	1.46	0.94	2.40	3.28	4.10	1.03	3.43	8.56	8.00	5.13	6.00	5.87	8.00	5.46	21.57	....	38.00	5132
5133	" " All Crop Fert..	......	0.68	0.91	1.59	2.46	4.06	1.11	5.48	10.65	8.00	5.17	6.00	2.94	2.00	2.73	17.06	....	32.00	5133
5202	Sharpless & Carpenter's No. 1 Bone P..	......	0.11	2.26	2.37	1.23	5.28	1.57	1.89	8.74	....	6.85	8.00	3.94	2.00	5.13	21.49	....	25.00	5202
5308	" " S.Tam. Guano	0.55	0.11	2.27	2.93	2.87	6.36	1.62	3.10	11.08	....	7.98	9.00	5.17	5.50	5.16	26.30	....	39.00	5308
5201	" " G. E. Potato...	......	0.11	2.20	2.31	2.46	5.00	1.83	3.15	9.98	....	6.83	6.00	6.98	5.00	8.23	24.49	....	35.00	5201
5439	" " 7 P. C. Potato.	0.94	3.44	1.65	6.03	5.74	3.30	2.71	1.76	7.77	7.00	6.01	6.00	4.64	6.00	3.11	33.18	....	42.50	5439
5224	Shoemaker's Swift-Sure Superphos......	0.72	......	2.26	2.98	2.46	7.46	2.15	4.84	14.45	14.00	9.61	9.00	4.03	4.00	4.37	28.21	....	33.00	5224
5415	" " for Potatoes...	0.78	......	1.82	2.60	2.46	7.28	2.50	4.22	14.00	14.00	9.78	9.00	5.85	5.00	5.91	28.46	....	37.50	5415
5124	Smith's Potato Fertilizer	0.17	0.28	3.85	4.30	4.10	5.74	1.65	2.95	10.34	....	7.39	6.00	4.05	3.00	3.86	29.40	....	35.00	5124
5059	" Bone Phosphate.....................	......	0.34	1.67	2.01	1.64	1.06	4.99	4 61	10.66	....	6.05	10.00	2.39	2.00	2.90	18.87	....	30.00	5059
5058	" Special Potato	......	0.14	2.50	2.64	2.46	6.80	1.42	1.62	9.84	....	8.22	6.00	6.39	7.00	6 09	26.32	....	38.00	5058
5540	Susquehanna Ammon. Bone Phos.......	......	......	1.34	1.34	1.23	7.86	1.69	2.65	12.20	11.00	9.55	9.00	1.36	1.50	2.83	19.39	....	28.00	5540
5283	Taylor's Peach Tree Formula..............	......	......	1.31	1.31	2.05	3.28	3.64	3.74	10.66	11.00	6.92	....	13.81	10.00	11.65	27.51	....	36.00	5283
5250	" Potato, Truck and Tobacco...	0.86	......	2.29	3.15	2.46	6.74	1.88	1.04	9.66	10.00	8.62	....	11.29	10.00	0.62	34.57	....	40.00	5250
5282	" Special Potato Fertilizer........	0.60	......	1.25	1.85	1.64	6.50	1.19	1.36	9.05	8.00	7.69	....	8.71	10.00	7.62	24.62	....	36.00	5282
5458	" H. G. Corn and Tr'k Manure.	......	0.79	1.46	2.25	2.46	4.50	2.97	4.47	11.94	10.00	7.47	....	5.44	5.00	5.47	24.20	....	35.00	5458

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.	BRAND.	MANUFACTURER.	SAMPLED BY.	Station Number.
5429	Dissolved Bone	The Taylor Provision Co., Trenton, N. J.	J. H. Denise, Freehold.	5429
5430	Wheat Fertilizer	" " " " " "	" " "	5430
5455	Bone, Tankage and Potash	" " " " " "	Woodnutt Pettit, Salem.	5455
5541	Ammoniated Dissolved Bone and Potash	" " " " " "	W. O. Ward, Hainesburg.	5541
5064	Truck Guano	I. P. Thomas & Sons Co., Philadelphia, Pa.	H. I. Budd, Mount Holly.	5064
5126	Tip-Top Raw Bone Superphosphate	" " " " " "	" " " "	5126
5597	Potato Manure	" " " " " "	J. M. White, New Brunswick.	5597
5363	Normal Bone Phosphate,	" " " " " "	G. S. Voorhees, Mine Brook.	5363
5285	Fish Guano	" " " " " "	Charles Kraus, Egg Harbor City.	5285
5203	High-Grade Bone Phosphate	" " " " " "	I. W. Nicholson, Camden.	5203
5225	Atkinson's Special Potato	" " " " " "	James C. Griscom, Woodbury.	5225
5595	Stults's No. 1 Wheat.	" " " " " "	J. M. White, New Brunswick.	5595
5596	Wheat and Grass Compound	" " " " " "	" " " "	5596
5061	No. 1 Potato Manure	" " " " " "	H. I. Budd, Mount Holly.	5061
5062	Wheat Manure	" " " " " "	" " " "	5062
5063	Tomato and Potato	" " " " " "	" " " "	5063
5190	Collins's Brand	" " " " " "	I. W. Nicholson, Camden.	5170

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.		Nitrogen. From Nitrates.	Nitrogen. From Ammonia Salts.	Nitrogen. From Organic Matter.	Nitrogen. Total Found.	Nitrogen. Total Guaranteed.	Phosphoric Acid. Soluble in Water.	Phosphoric Acid. Soluble in Ammonium Citrate.	Phosphoric Acid. Insoluble.	Phosphoric Acid. Total Found.	Phosphoric Acid. Total Guaranteed.	Phosphoric Acid. Available. Found.	Phosphoric Acid. Available. Guaranteed.	Potash. Found.	Potash. Guaranteed.	Chlorine.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Factory.	Selling Price of 2,000 lbs. at Consumers' Depot.	Station Number.
5429	Taylor's Dissolved Bone..........	......	......	2.00	2.00	1.64	6.96	1.02	2.45	10.43	9.00	7.98	....	3.96	3.00	3.30	$21.92	....	$30.00	5429
5430	" Wheat Fertilizer..........	......	......	2.30	2.30	2.46	9.04	1.16	2.65	12.85	10.00	10.20	....	2.97	2.50	2.71	25.04	....	32.00	5430
5455	" Bone, Tankage and Pot...	......	......	1.20	1.20	0.82	3.82	1.67	1.67	7.16	8.00	5.49	....	2.68	2.50	2.58	14.42	....	25.00	5455
5541	" Am. Diss. Bone and Pot...	0.12	......	1.04	1.16	1.23	4.50	2.82	2.70	10.02	8.00	7.32	....	2.96	2.50	4.65	17.27	....	25.00	5541
5064	Thomas's Truck Guano..........	0.10	0.11	1.05	1.26	0.82	7.46	1.11	1.89	10.46	9.00	8.57	7.00	2.27	1.50	4.46	18.30	....	27.00	5064
5126	" Tip-Top Raw Bone Sup...	0.76	0.11	2.30	3.17	2.46	9.56	0.78	0.97	11.31	13.00	10.34	10.00	3.37	2.75	3.69	27.64	....	34.00	5126
5597	" Potato Manure	1.25	......	1.75	3.00	2.46	6.44	2.19	3.05	11.68	11.00	8.63	9.00	6.62	6.00	4.60	28.52	....	39.00	5597
5363	" Normal Bone Phosphate.	......	......	1.20	1.20	1.03	8.06	1.22	1.95	11.23	10.50	9.28	8.50	1.74	1.50	3.78	18.62	....	26.00	5363
5285	" Fish Guano..........	......	......	2.05	2.05	1.23	7.62	1.39	1.60	10.61	11.00	9.01	9.00	2.82	2.00	4.08	22.08	....	29.00	5285
5203	" H. G. Bone Phosphate....	1.29	6.51	1.97	9.77	7.38	4.60	0.16	0.26	5.02	8.50	4.76	7.00	4.92	3.00	5.00	43.75	....	48.00	5203
5225	" Atkinson's Spec. Potato..	0 73	1.22	2.06	4.01	3.69	5.28	4.09	2.50	11.87	....	9.37	9.00	6.37	6.00	6.33	32.53	....	34.00	5225
5595	" Stults's No. 1 Wheat.......	0.60	......	1.37	1.97	1.64	6.68	1.63	4.16	12.47	....	8.31	8.00	3.57	2.00	2.61	22.36	....	33.00	5595
5596	" Wheat and Grass Comp...	0.53	0.13	1.85	2.51	0.82	2.24	4.92	6.36	13.52	11.00	7.16	10.00	4.87	1.00	5.59	24.79	....	28.00	5596
5061	" No. 1 Potato Manure.......	1.48	0.28	1.76	3.52	2.46	7.04	0.77	1.50	9.31	11.00	7.81	9.00	7.39	6.00	6.46	29.10	....	38.00	5061
5062	" Wheat Manure..........	0.78	0.11	1.03	1.92	1.23	7.36	1.21	1.61	10.18	10.50	8.57	8.50	3.18	1.50	4.54	21.04	....	28.00	5062
5063	" Tomato and Potato.........	1.18	0.16	0.33	1.67	1.44	6.92	0.65	1.36	8.93	10.50	7.57	9.00	9.27	6.00	10.45	24.09	....	34.00	5063
5190	" Collins's Brand..........	1.52	1.60	0.62	3.74	2.46	9.14	0.85	1.40	11.39	11.00	9.99	....	5.05	6.00	4.91	30.42	....	32.00	5190

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.	BRAND.	MANUFACTURER.	SAMPLED BY.	Station Number.
5561	Complete Manure	Jas. M. Thorburn & Co., New York City.	Dayton N. Warbasse, Huntsburg.	5561
5604	Corn Mixture	Trenton Bone Fert. Co., Trenton, N. J.	Franklin Dye, Trenton.	5604
5605	Bone Phosphate	" " " " " "	" " "	5605
5606	Potato Fertilizer	" " " " " "	" " "	5606
5607	XX. Brand	" " " " " "	" " "	5607
5608	Ammoniated Dissolved Bone	" " " " " "	" " "	5608
5609	Potato Fertilizer, Special	" " " " " "	" " "	5609
5610	Standard Fertilizer	" " " " " "	" " "	5610
5612	Complete, for Corn and Truck	" " " " " "	" " "	5612
5613	High-Grade Truck Fertilizer	" " " " " "	" " "	5613
5522	Bone Phosphate	The J. E. Tygert Co., Philadelphia, Pa.	Theo. F. D. Baker, Bridgeton.	5522
5432	Potato Guano	" " " " "	J. H. Denise, Freehold.	5432
5521	Guano	" " " " "	Theo. F. D. Baker, Bridgeton.	5521
5287	Fish, Bone and Potash	" " " " "	Chas. Kraus, Egg Harbor City.	5287
5129	" " " "	The Tygert-Allen Fertilizer Co., Philadelphia, Pa.	H. I. Budd, Mount Holly.	5129
5229	Potato Manure	" " " " " "	James C. Griscom, Woodbury.	5229
5127	Nitro-Phosphate	" " " " " "	H. I. Budd, Mount Holly.	5127

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.		Nitrogen.					Phosphoric Acid.							Potash.						
												Available.								
		From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Chlorine.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Factory.	Selling Price of 2,000 lbs. at Consumers' Depot.	Station Number.
5561	Thorburn's Complete Manure	......	0.23	2.34	2.57	2.46	2.68	4.85	3.33	10.86	....	7.53	8.00	4.11	7.00	2.26	$24.01	....	$35.00	5561
5604	Trenton Corn Mixture	0.23	......	1.93	2.16	1.64	1.76	3.29	3.30	8.35	....	5.05	7.00	3.69	3.00	3.58	18.68	....	27.00	5604
5605	" Bone Phosphate	0.22	0.26	1.86	2.34	1.64	2.50	4.65	4.59	11.74	....	7.15	10.00	3.04	2.00	4.85	21.95	....	30.00	5605
5606	" Potato Fertilizer	0.76	0.14	2.53	3.43	2.46	0.80	4.95	4.68	10.43	10.00	5.75	9.00	10.23	10.00	9.89	30.26	....	40.00	5606
5607	" XX. Brand	0.20	......	1.09	1.29	0.82	6.74	1.59	2.34	10.67	....	8.33	9.00	2.32	2.00	4.66	18.30	....	25.00	5607
5608	" Ammon. Dissolved Bone	0.33	......	1.59	1.92	1.64	3.12	4.41	3.86	11.39	....	7.53	8.00	2.04	1.50	3.99	19.76	....	28.00	5608
5609	" Potato Fertilizer, Special	0.81	0.11	2.50	3.42	2.46	1.02	4.80	5.57	11.39	....	5.82	8.00	7.64	7.00	7.70	28.31	....	36.00	5609
5610	" Standard Fertilizer	0.41	0.11	2.11	2.63	2.05	4.70	4.88	2.83	12.41	....	9.58	10.00	2.90	2.50	4.03	25.22	....	33.00	5610
5612	" Complete for Corn and Truck	0.50	0.12	2.16	2.78	2.46	1.96	4.33	4.61	10.90	10.00	6.29	9.00	6.14	5.00	5.56	25.07	....	35.00	5612
5613	" High-Grade Truck Fertilizer	0.96	0.14	2.65	3.75	3.28	1.02	5.29	4.72	11.03	....	6.31	10.00	9.98	10.00	8.65	31.82	....	45.00	5613
5522	Tygert's Bone Phosphate	0.97	......	0.73	1.70	1.85	2.60	5.49	2.69	10.78	11.00	8.09	9.00	2.49	2.50	2.04	19.41	....	25.00	5522
5432	" Potato Guano	0.39	0.96	0.38	1.73	2.05	6.30	2.13	1.34	9.77	9.00	8.43	7.00	5.74	7.00	2.38	22.99	....	36.00	5432
5521	" Guano	0.97	......	0.81	1.78	2.27	2.48	4.90	3.15	10.53	9.50	7.38	7.50	3.19	3.50	3.00	19.57	....	25.00	5521
5287	" Fish, Bone and Potash	1.09	......	0.79	1.88	2.05	5.68	1.21	1.14	8.03	7.50	6.89	6.00	3.28	3.00	1.51	18.77	....	35.00	5287
5129	Tygert-Allen's Fish, Bone and Potash	......	......	2.76	2.76	3.28	6.00	1.79	2.63	10.42	8.00	7.79	5.00	5.29	3.00	5.64	25.60	....	33.00	5129
5229	" " Potato Manure	0.78	1.05	1.37	3.20	3.28	5.44	1.47	1.58	8.49	9.00	6.91	6.00	9.07	9.00	9.04	28.56	....	39.00	5229
5127	" " Nitro-Phosphate	......	0.14	1.72	1.86	1.64	5.94	2 43	3.23	11.60	....	8.37	8.50	2.60	2.50	2.82	21.01	....	30.00	5127

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.	BRAND.	MANUFACTURER.	SAMPLED BY.	Station Number.
5227	Soluble Marine Guano	The Tygert-Allen Fertilizer Co., Philadelphia, Pa.	James C. Griscom, Woodbury.	5227
5523	Star Bone Phosphate	" " " " " "	Theo. F. D. Baker, Bridgeton.	5523
5067	Standard Bone Phosphate	" " " " " "	H. I. Budd, Mount Holly.	5067
5228	Special Potato Manure	" " " " " "	James C. Griscom, Woodbury.	5228
5433	Cabbage Manure	" " " " " "	J. H. Denise, Freehold.	5433
5309	Potato Manure	Wm. R. Van Gilder, Petersburg, N. J.	J. H. Richardson, Rio Grande.	5309
5614	Big Bonanza Fertilizer	Walker, Stratman & Co., Pittsburgh, Pa.	Franklin Dye, Trenton.	5614
5314	Peerless Potato Manure	Walton & Whann, Wilmington, Del.	I. W. Nicholson, Camden.	5314
5465	Ammoniated Dissolved Bone	" " " "	Woodnutt Pettit, Salem.	5465
5464	Excelsior Bone Phosphate	" " " "	" " "	5464
5310	Cereal Bone Phosphate	" " " "	J. H. Richardson, Rio Grande.	5310
5136	Plow Brand	" " " "	H. I. Budd, Mount Holly.	5136
5074	O. K. Potato Manure	Geo. M. Wells, Moorestown, N. J.	" " " "	5074
5075	O. K. Fish Guano	" " " "	" " " "	5075
5205	Potato Fertilizer	J. Wenderoth & Sons, Camden, N. J.	I. W. Nicholson, Camden.	5205
5206	Equine Guano	" " " " "	" " "	5206
5315	Favorite	" " " " "	" " "	5315

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.		Nitrogen.					Phosphoric Acid.							Potash.		Chlorine.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Factory.	Selling Price of 2,000 lbs. at Consumers' Depot.	Station Number.
		From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble	Total Found.	Total Guaranteed.	Available. Found.	Available. Guaranteed.	Found.	Guaranteed.					
5227	Tygert-Allen's Soluble Marine Guano..	0.70	1.25	1.74	3.69	3.69	6.36	1.23	1.73	9.32	9.00	7.59	7.00	5.47	5.00	5.51	$27.99	....	$42.00	5227
5523	" " Star Bone Phosphate.....	......	0.16	1.94	2.10	2.05	6.34	1.85	3.06	11.25	10.50	8.19	8.50	2.57	2.50	2.93	21.51	....	25.00	5523
5067	" " Standard Bone Phos.....	......	0.17	1.78	1.95	1.64	7.24	1.50	1.81	10.55	....	8.74	8.00	2.25	2.00	2.21	20.92	....	25.00	5067
5228	" " Special Potato Manure.	.....	0.23	2.04	2.27	2.05	5.12	1.41	2.38	8.91	....	6.53	6.00	5.12	6.00	5.03	21.97	....	34.00	5228
5433	" " Cabbage Manure.........	1.07	1.08	1.44	3.59	3.69	5.52	1.99	1.94	9.45	....	7.51	7.00	5.24	5.00	5.49	27.30	....	44.00	5433
5309	Van Gilder's Potato Manure................	0.44	0.44	1.95	2.83	2.46	7.92	0.90	1.44	10.26	11.00	8.82	9.00	5.64	6.00	5.16	26.82	....	36.00	5309
5614	Walker-Stratman's Big Bonanza	......	0.16	2.09	2.25	2.46	6.44	2.13	6.15	14.72	12.00	8.57	10.00	1.05	1.08	0.79	22.41	....	33.00	5614
5314	Walton & Whann's Peerless Potato......	......	0.29	3.19	3.48	3.28	2.28	3.39	6.21	11.88	....	5.67	7.00	6.74	9.00	7.13	28.08	....	32.00	5314
5465	" " Am. Diss. Bone.....	......	......	2.18	2.18	2.05	7.20	2.01	1.59	10.80	12.00	9.21	10.00	3.66	3.00	4.07	23.53	....	30.00	5465
5464	" " Excelsior B. Phos.	......	0.72	0.98	1.70	1.23	7.90	2.06	2.12	12.08	12.00	9.96	10.00	2.14	2.00	2.35	21.61	....	25.00	5464
5310	" " Cereal Bone Phos.	......	......	1.93	1.93	1.64	5.82	2.14	3.53	11.49	10.00	7.96	8.00	4.97	5.00	6.76	22.99	....	30.00	5310
5136	" " Plow Brand	......	0.14	2.26	2.40	2.26	4.44	1.87	4.89	11.20	12.00	6.31	9.00	2.06	2.25	2.35	20.40	....	29.00	5136
5074	Wells's O. K. Potato Manure	0.58	0.83	1.84	3.25	3.28	5.26	1.86	1.04	8.16	7.00	7.12	6.00	7.35	8.00	7.28	27.36	....	36.00	5074
5075	" " Fish Guano.....................	0.65	......	2.01	2.66	2.46	5.16	2.11	1.69	8.96	7.00	7.27	5.00	3.53	5.00	3.74	22.37	....	30.00	5075
5205	Wenderoth's Potato Fertilizer.............	......	......	2.95	2.95	3.28	6.56	1.98	3.25	11.79	9.00	8.54	7.00	3.92	5.00	1.98	26.52	....	35.00	5205
5206	" Equine Guano................	......	......	3.00	3.00	3.28	6.00	2.48	4.39	12.87	9.00	8.48	7.00	0.79	1.00	0.65	23.99	....	32.00	5206
5315	" Favorite	......	0.14	6.28	6.42	5.74	0.38	5.29	7.49	13.16	11.00	5.67	....	3.78	4.00	2.65	36.29	....	38.00	5315

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.	BRAND.	MANUFACTURER.	SAMPLED BY.	Station Number.
5316	$25 Fertilizer	J. Wenderoth & Sons, Camden, N. J.	I. W. Nicholson, Camden.	5316
5073	Chester Valley Special Potato and Truck	Wm. E. Whann, Atglen, Pa.	H. I. Budd, Mount Holly.	5073
5072	Chester Valley Raw Bone Superphosphate	" " " "	" " " "	5072
5585	Americus Ammoniated Bone Superphosphate	Williams & Clark Fertilizer Co., New York.	J. B. Eckerson, River Vale.	5585
5498	Americus Potato Phosphate	" " " " " "	J. J. Mitchell, Troy Hills.	5498
5070	Americus High-Grade Special for Market Truck	" " " " " "	H. I. Budd, Mount Holly.	5070
5339	Ammoniated Dissolved Bones	" " " " " "	Augustus Dilts, Copper Hill.	5339
5230	Royal Bone Phosphate	" " " " " "	J. C. Griscom, Woodbury.	5230
5341	Peach Tree Fertilizer	" " " " " "	Augustus Dilts, Copper Hill.	5341
5628	Champion	F. B. Young, Pennington, N. J.	J. J. Sharp, Pattenburg.	5628

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Station Number.		Nitrogen. From Nitrates.	Nitrogen. From Ammonia Salts.	Nitrogen. From Organic Matter.	Nitrogen. Total Found.	Nitrogen. Total Guaranteed.	Phosphoric Acid. Soluble in Water.	Phosphoric Acid. Soluble in Ammonium Citrate.	Phosphoric Acid. Insoluble.	Phosphoric Acid. Total Found.	Phosphoric Acid. Total Guaranteed.	Phosphoric Acid. Available. Found.	Phosphoric Acid. Available. Guaranteed.	Potash. Found.	Potash. Guaranteed.	Chlorine.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Factory.	Selling Price of 2,000 lbs. at Consumers' Depot.	Station Number.
5316	Wenderoth's $25 Fertilizer.	......	0.38	1.54	1.92	1.64	7.04	3.14	2.59	12.77	12.00	10.18	11.00	0.60	1.00	0.27	$21.53	....	$25.00	5316
5073	Whann's Chester Valley Special Potato....	0.83	......	1.80	2.63	2.05	4.08	2.22	4.01	10.31	11.00	6.30	8 00	4.26	4.00	5.20	22.49	....	32.00	5073
5072	" " " Raw Bone Super	0.72	......	1.52	2.24	1.64	4.62	2.01	3.03	9.66	11.00	6.63	8.00	3.76	3.00	5.86	20.76	....	32.00	5072
5585	Williams & Clark's Amer. A Bone Super...	......	0.17	2.48	2.65	2.46	5.42	3.32	2.42	11.16	10.00	8.74	9.00	1.87	2.00	2.45	23.28	....	38.00	5585
5498	" " Americus Potato Phos	......	0.15	2.42	2.57	2.46	4.66	2.23	1.22	8.11	7.00	6.89	6.00	4.60	5.00	6.74	22.57	....	37.00	5498
5070	" " Am. H. G. Sp for M. T.	......	1.19	2.29	3.48	3.69	4.62	3.04	1.80	9.46	8.00	7.66	7.00	7.53	7.00	5.06	29.70	....	42.00	5070
5339	" " Ammon. Diss. Bones..	......	0.17	1.63	1.80	1.64	4.00	4.05	4.21	12.26	9.00	8.05	8.00	2.15	2.00	2.35	20.38	....	29.00	5339
5230	" " Royal Bone Phos.......	......	0.18	1.13	1.31	1.03	3.70	3.59	2.58	9.87	8.00	7.29	7.00	1.98	2.00	3.39	16.86	....	26.00	5230
5341	" " Peach Tree Fert.........	......	0.20	1.53	1.73	1.23	......	2.04	9.32	11.36	12.00	2.04	....	4.09	4.32	3.39	16.10	....	29.00	5341
5628	Young's Champion............................	0.70	......	1.27	1.97	1.85	6.94	1.11	3.60	11.65	11.00	8.05	9.00	2.84	2.50	2.76	21.08	....	23.00	5628

Ground Bone

Furnishing Nitrogen and Insoluble Phosphoric Acid.

Station No.	BRAND.	MANUFACTURER.	SAMPLED BY.	Station No.
5591	Pure Ground Bone	Allentown Mfg. Co., Allentown, Pa.	J. M. White, New Brunswick.	5591
5163	Ground Bone	H. J. Baker & Bro., New York City.	M. S. Crane, Caldwell.	5163
5263	Raw Bone, Fine	The Berg Co., Philadelphia, Pa.	C. Kraus, Egg Harbor City.	5263
5054	Steamed Bone	" " " "	H. I. Budd, Mount Holly.	5054
5030	Pure Ground Bone	Peter Cooper's Glue Factory, New York.	" "	5030
5572	" " "	Crocker Fertilizer and Chemical Co., Buffalo, N. Y.	J. B. Eckerson, River Vale.	5572
5506	" Bone Meal	Garrison & Minch, Bridgeton, N. J.	T. F. D. Baker, Bridgeton.	5506
5372	" Ground Bone	Great Eastern Fertilizer Co., Rutland, Vt.	G. S. Voorhees, Mine Brook.	5372
5375	Bone Manure	S. M. Hess & Bro., Reading, Pa.	" "	5375
5492	Pure Ground Bone, Fine	The Mapes F. and P. Guano Co., New York.	J. J. Mitchell, Troy Hills.	5492
5200	Button Bone	L. Moritz, Philadelphia, Pa.	I. W. Nicholson, Camden.	5200
5556	Pure Bone and Potash	Preston Fertilizer Co., Green Point, L. I.	D. N. Warbasse, Huntsburg.	5656
5558	Ground Bone, or Bone Dust	" " " "	" "	5558
5247	Pure Ground Bone	" " " "	J. H. Denise, Freehold.	5247
5624	Bone Meal	B. F. Ruckman & Son, New Brunswick, N. J.	I. Hutchinson, New Brunswick.	5624
5020	Pure Bone	Schneider & Schwartz, Pluckamin, N. J.	J. Fenner, Jr., Pluckamin.	5020
5462	" Fine Ground Raw Bone	Scott Fertilizer Co., Elkton, Md.	W. Pettit, Salem.	5462
5441	" Ground Bone	Sharpless & Carpenter, Philadelphia, Pa.	G. A. MacBean, Lakewood.	5441
5078	Bone Meal	The Taylor Provision Co., Trenton, N. J.	Station.	5078
5611	Pure Fine Ground Bone	Trenton Bone Fertilizer Co., Trenton, N. J.	F. Dye, Trenton.	5611
5317	" Ground Bone	J. Wenderoth & Son, Camden, N. J.	I. W. Nicholson, Camden.	5317
5071	Carteret Bone Meal	Williams & Clark Fertilizer Co., New York.	H. I. Budd, Mount Holly.	5071
5300	Bone Sawings	Saml. Winterbottom, Egg Harbor City, N. J.	J. C. Kraus, Egg Harbor City.	5300

Ground Bone

Furnishing Nitrogen and Insoluble Phosphoric Acid.

Station Number.		Mechanical Analysis.				Chemical Analysis.		Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.	Station Number.
		Finer than 1-50th in.	Finer than 1-25th in.	Finer than 1-12th in.	Coarser than 1-12th in.	Nitrogen.	Phosphoric Acid.			
5591	Allentown Pure Ground Bone	26	25	23	26	4.55	19.91	$27.79	$36.00	5591
5163	Baker's Ground Bone	46	50	4	....	3.78	23.99	36.04	28.00	5163
5263	Berg's Raw Bone, Fine	18	24	34	24	3.73	19.96	25.09	32.00	5263
5054	" Steamed Bone	45	29	14	12	3.54	8.96	17.82	27.50	5054
5030	Cooper's Pure Ground Bone	66	17	10	7	1.58	29.98	36.71	23.00	5030
5572	Crocker's Pure Ground Bone	26	30	32	12	3.92	22.35	29.81	38.00	5572
5506	Garrison & Minch's Pure Bone Meal	37	48	15	....	4.01	21.86	32.97	30.00	5506
5372	Great Eastern Pure Ground Bone	48	18	14	20	1.81	28.01	32.02	35.00	5372
5375	Hess's Bone Manure	34	31	28	7	4.45	21.18	31.36	35.00	5375
5492	Mapes's Pure Ground Bone, Fine	39	17	18	26	2.97	25.23	30.40	34.00	5492
5200	Moritz's Button Bone	35	30	28	7	4.01	24.87	34.03	33.00	5200
5556	Preston's Pure Bone and Potash	33	46	21	....	2.47	*9.15	20.66	29.00	5556
5558	" Ground Bone, or Bone Dust	38	19	15	28	4.16	†7.17	18.97	27.00	5558
5247	" Pure Ground Bone	45	38	17	....	3.58	22.75	33.22	35.00	5247
5624	Ruckman's Bone Meal	21	18	45	16	4.46	22.33	29.18	30.00	5624
5020	Schneider & Schwartz's Pure Bone	60	26	13	1	2.59	15.97	24.32	35.00	5020
5462	Scott's Pure Fine Ground Raw Bone	33	27	30	10	4.16	22.59	31.46	34.00	5462
5441	Sharpless & Carpenter's Pure Ground Bone	49	40	11	....	4.12	21.58	34.04	34.00	5441
5078	Taylor's Bone Meal	78	20	2	....	3.53	21.10	34.39	30.00	5078
5611	Trenton Pure Fine Ground Bone	24	29	30	17	4.53	21.10	29.34	32.00	5611
5317	Wenderoth's Pure Ground Bone	22	26	28	24	3.81	23.34	28.92	34.00	5317
5071	Williams & Clark's Carteret Bone Meal	56	23	21	....	2.43	15.18	22.58	32.00	5071
5300	Winterbottom's Bone Sawings	90	9	1	....	3.68	25.52	40.85	30.00	5300

* Contains 4.91 potash and 0.81 chlorine. † Contains 2.94 potash and 1.30 chlorine.

Miscellaneous Fertilizing Materials.

Station Number.	BRAND.	MANUFACTURER.	SAMPLED BY.	Station Number.
5117	$25 Phosphate	Baugh & Sons' Co., Philadelphia, Pa.	H. I. Budd, Mount Holly.	5117
5418	Dissolved Raw Bone	The Berg Co , Philadelphia, Pa.	J. H. Denise, Freehold.	5418
5092	Fresh Ground Bone	Bowker Fertilizer Co., New York.	D. C. Crane, Westfield.	5092
5333	Pure Fine Bone, Dissolved	The Mapes F. and P. Guano Co., New York.	A. Dilts, Copper Hill.	5333
5621	Dissolved Bone	Newark Chemical Works, Newark, N. J.	J. Voorhees, South Branch.	5621
5461	Pure Dissolved Animal Bone	Scott Fertilizer Co., Elkton, Md.	W. Pettit, Salem.	5461
5598	Raw and Dissolved Bone	The I. P. Thomas & Son Co., Philadelphia, Pa.	J. M. White, New Brunswick.	5598
5060	Improved Superphosphate	" " " " " " "	H. I Budd, Mount Holly.	5060
5226	Superior Fish Guano	The Tygert-Allen Fert. Co., Philadelphia, Pa.	J. C. Griscom, Woodbury.	5226
5019	Flesh, and Bone	Schneider & Schwartz, Pluckamin, N. J.	J. Fenner, Jr., Pluckamin.	5019
5349	Dissolved Bone and Potash	E. Frank Coe Co., New York City.	G. S. Voorhees, Mine Brook.	5349
5340	" " "	Williams & Clark Fert. Co., New York City.	A. Dilts, Copper Hill.	5340
5223	Odorless Phosphate	Pottstown Iron Co., Pottstown, Pa.	J. C. Griscom, Woodbury.	5223
5622	Acid Phosphate	Walton, Whann & Co., Wilmington, Del.	H. I. Budd, Mount Holly.	5622

Miscellaneous Fertilizing Materials.

Station Number.		Nitrogen.					Phosphoric Acid.							Potash.		Chlorine.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Factory.	Selling Price of 2,000 lbs. at Consumers' Depot.	Station Number.
		From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Available. Found.	Available. Guaranteed.	Found.	Guaranteed.					
5117	Baugh's $25 Phosphate.	...	0.28	2.63	**2.91**	**2.05**	7.00	1.30	3.32	**11.62**	...	**8.30**	**7.00**	...	...	...	**$22.28**	...	**$25.00**	5117
5418	Berg's Dissolved Raw Bone	...	...	2.14	**2.14**	**1.64**	5.60	3.56	4.50	**13.66**	...	**9.16**	**10.00**	...	...	...	**21.20**	...	**32.00**	5418
5092	Bowker's Fresh Ground Bone	...	...	3.66	**3.66**	**2.46**	2 28	10.33	5.05	**17.66**	**18.00**	**12.61**	**5.00**	...	...	...	**31.22**	...	**33.00**	5092
5333	Mapes's Pure Fine Bone, Dissolved	...	...	3.14	**3.14**	**2.05**	0.48	15.21	4.59	**20.28**	...	**15.69**	**12.00**	...	...	...	**33.22**	...	**34.00**	5333
5621	Newark Dissolved Bone	...	...	1.92	**1.92**	**2.00**	3.16	6.68	4.98	**14.82**	...	**9.84**	**10.00**	...	...	...	...	...	*	5621
5461	Scott's Pure Dissolved Animal Bone	...	...	1.88	**1.88**	**2.05**	6.08	6.36	7.91	**20.35**	**15.00**	**12.44**	**13.00**	...	...	...	**25.91**	...	**32.00**	5461
5598	Thomas's Raw and Dissolved Bone	...	...	1.10	**1.10**	**1.64**	5.80	3.50	9.10	**18.40**	**18.00**	**9.30**	**8.00**	...	...	...	**19.58**	...	**32.00**	5598
5060	" Improved Superphosphate	...	1.36	0.76	**2.12**	**0.41**	10.66	0.80	1.60	**13.06**	**14.00**	**11.46**	**12.00**	...	...	...	**22.82**	...	**25.00**	5060
5226	Tygert-Allen Superior Fish Guano	...	...	2.40	**2.40**	...	...	...	...	**5.58**	...	...	...	...	...	...	**13.98**	...	**25.00**	5226
5019	Schneider & Schwartz's F. and B.	...	...	4.34	**4.34**	...	...	...	...	**4.90**	...	...	...	...	...	...	**14.97**	...	**30.00**	5019
5349	Coe's Dissolved Bone and Potash	...	...	...	...	...	5.76	3.32	3.97	**13.05**	**14.00**	**9.08**	**12.00**	**2.70**	**2.75**	0.34	**16.29**	...	**26.00**	5349
5340	W. & C.'s Diss. Bone and Potash	...	...	...	...	...	2.08	7.03	3.31	**12.42**	**10.00**	**9.11**	...	**2.04**	**2.00**	5.54	**15.00**	...	**24.00**	5340
5223	Pottstown Odorless Phosphate	...	...	...	...	...	...	4.68	13.73	**18.41**	...	**4.68**	...	...	...	...	**11.57**	...	†	5223
5622	Walton & Whann's Acid Phosphate	...	...	...	...	...	13.34	2.15	1.57	**17.06**	**17.00**	**15.49**	**16.00**	...	...	...	...	...	‡	5622

* $2 per unit for ammonia; $1 per unit for available phosphoric acid. † $0.85 per unit for available phosphoric acid. ‡ $15 per ton, in car lots, f. o. b. Pottstown.

Canada Ashes.

Station Number.	MANUFACTURER.	SENT BY.
5022	C. Stevens, Napanee, Ont., Canada.	E. Williams, Montclair.
5027	Forest City Wood Ash Co., Boston, Mass.	W. H. Ellis, Hammonton.
5114	F. Lalor, Danville, Ont., Canada.	D. C. Crane, Westfield.
5426	Monroe, De Forest & Co., Oswego, N. Y.	J. H. Denise, Freehold.
*5562	Winsor Lime Co., Hamburg, N. J.	D. N. Warbasse, Huntsburg.
5620	Allison, Stroup & Co., New York City.	R. Pond, Vineland.
5629	" " " " "	J. Fitzga, Somerville.
5630		A. A. Clark, Somerville.

*Lime kiln ashes.

	5022	5027	5114	5426	5562	5620	5629	5630
Phosphoric Acid..........	1.61	1.22	1.57	1.48	1.13	0.95	1.06	1.21
Potash..........................	5.96	5.92	4.78	4.44	0.54	3.90	4.95	3.32
Lime............................	34.02	31.53	36.00	26.16	37.08	45.76	35.68	34.74
Valuation Per Ton........	$8.17	$7.73	$6.83	$6.36	$1.72	$5.24	$6.51	$4.86
Selling Price Per Ton...	12.00	12.00	13.00	15.00	†	13.00	11.00	11.00

† Selling price, 12½ cts. per bushel.

Station Number.	From A. H. Hawley, Vineland, N. J.	Moisture.	Organic Matter.	Ash.	Nitrogen.	Phosphoric Acid. Total.	Phosphoric Acid. Available.	Potash.	Lime.	Valuation per ton.
5024	Belgian Hare Manure.....	50.94	44.35	4.71	1.10	0.58	0.50	0.58	1.01	$5.12
5025	Pigeon Manure................	72.66	20.68	6.66	1.34	0.82	0.73	0.43	1.67	6.13
5026	Hen Manure....................	73.58	16.62	9.80	1.23	1.12	1.01	0.44	2.51	6.11

5021. Wool Waste. J. Story, Philadelphia, Pa. Sent by A. McCullough, Folsom. It contains 2.42 nitrogen, 0.50 total phosphoric acid, and 2.10 per cent. potash. Valuation, $6.41; selling price, $7 per ton.

5125. Cotton-Seed Hulls. Tennessee Cotton Oil Co., Memphis, Tenn. Sent by H. I. Budd, Mount Holly. It contains 0.69 nitrogen, 0.56 total phosphoric acid, and 1.08 per cent. potash. Selling price, $9 per ton.

5210. Marl. Sent by C. M. Patterson, Red Bank, N. J. It contains 0.87 total phosphoric acid, 0.11 potash and 0.36 per cent. lime. Selling price, 50 cents per ton.

5625. Dried Swamp Muck. Sent by H. H. Riggs, Hightstown, N. J. It contains 1.24 nitrogen, 0.56 total phosphoric acid, 0.22 potash and 0.50 per cent. lime.

III.

AGRICULTURAL RELATIONS OF FERTILIZERS.

1.

EXPERIMENT WITH FERTILIZERS UPON TOMATOES.

BY J. W. GILL, TOMLIN STATION, GLOUCESTER COUNTY.

Five field experiments with nitrate of soda on tomatoes, according to the plan here reported, have been carried out by the Station previous to this year. Those in 1889 and 1890 were upon the same farm, in Middlesex county, on land in a high state of cultivation and considered as especially suitable for the crop. In 1891 the experiments were upon different farms, one in Middlesex county and the other in Gloucester county.

The experiments in Gloucester county in 1891, 1892 and 1893 were carried out upon different parts of the same farm. The soils in these experiments were of good physical character and well adapted for the crop, though that of the experiment in Middlesex county in 1891 was poor in plant-food. The management of the experiment crops conformed in all cases to the practice of the most successful growers.

The principal conclusion from a study of the results secured from all of these experiments is:

That nitrate of soda properly used is a profitable fertilizer for early tomatoes.

LOCATION OF EXPERIMENT AND DESCRIPTION OF SOIL.

The experiment this year was carried out on the farm of Mr. J. W. Gill, at Tomlin Station, near Swedesboro, Gloucester county, a section largely devoted to raising tomatoes for the early markets. The land

was a sandy loam and in a good state of cultivation and fertility. The field had been cropped and manured as follows: Clover in 1890, corn in 1891, sweet potatoes in 1892, and manure at the rate of ten tons per acre applied for the sweet potatoes in 1892.

The following tabular statement shows the number of plots, the amounts of fertilizer used and the dates of its application; owing to the condition of the field it was impossible to include two unfertilized plots that were believed to be uniform in character.

Number of Plot.	KIND OF FERTILIZER.	Quantity.	DATE OF APPLICATION OF NITRATE OF SODA. May 10th.	DATE OF APPLICATION OF NITRATE OF SODA. May 31st.
1	Unfertilized	....	....	....
2	Nitrate of Soda	8 lbs.	8 lbs.	....
3	Nitrate of Soda	8 "	4 "	4 lbs.
4	Nitrate of Soda	16 "	16 "	....
5	Nitrate of Soda	16 "	8 "	8 lbs.
6	Muriate of Potash Bone Black	8 " 16 "	....	....
7	Nitrate of Soda Bone Black Muriate of Potash	8 " 16 " 8 "	8 lbs.	....
8	Nitrate of Soda Bone Black Muriate of Potash	8 " 16 " 8 "	4 "	4 lbs.
9	Nitrate of Soda Bone Black Muriate of Potash	16 " 16 " 8 "	16 "	....
10	Nitrate of Soda Bone Black Muriate of Potash	16 " 16 " 8 "	8 "	8 lbs.
11	Barnyard Manure	1 ton.	....	....
12	Unfertilized	....	....	....

APPLICATION OF FERTILIZERS.

With the exception of the second application of nitrate of soda, all fertilizers were applied and well worked into the soil previous to setting the plants. The mixed minerals for plots 6, 7, 8, 9 and 10, and the manure on plot 11, were applied broadcast over the whole of each plot.

Each application of nitrate of soda was distributed evenly over about one-half of the space occupied by the row.

FIELD RECORD.

An early variety was used, and the seeds from which the plants were secured were planted under glass in February. All plants were strong and healthy when set in the field.

The plants were set and fertilizers applied on May 10th. The plots were 9 x 242 feet, the rows being 4½ feet apart and the plants 4½ feet apart in the rows. The second application of nitrate was made on May 31st, at which time the plants were growing nicely. All cultivation was done lenthwise of the plots, often enough to keep them free from weeds and the land in good condition. Observations made on July 10th showed the plants on the blank plot, while of good color, less vigorous than on the fertilized plots. Plants on plots 2, 3, 4 and 5, with nitrate alone, were much darker in color than those on plots 7, 8, 9 and 10, though with no particular difference in size; on plot 6, with minerals alone, the plants were quite as large as on the nitrated plots, though much lighter in color; on plot 11, treated with barnyard manure, the vines were as large as upon any of the plots.

This is in accord with the report of observations made in previous years.

As reported in previous years, the tomatoes on plots 2, 3, 4 and 5 were smoother than upon the other plots, and larger than upon those plots which received the nitrate and minerals, or the minerals alone.

DISCUSSION OF RESULTS.

As in former experiments, the results represented as nearly as possible the actual practice of farmers growing the crop for the general market. An exact copy of the yield from the plots at different pickings, arranged to correspond with the different returns received, is shown in the following table :

TABLE 1.

Yield and Selling Price of Tomatoes at Different Pickings.

Number of Plot.		July 5.	July 8.	July 10.	July 12.	July 14.	July 15.	July 17.	July 19.	July 21.	July 22.	July 24.	July 25.	July 27.	July 29.	July 31.	August 2.	August 3.	August 5.	August 7.	August 9.	Total Yield per Plot.	Total Value per Plot.
2	Pounds	2.0	14.5	16.8	19.0	8.3	14.0	20.0	28.0	47.0	28.0	89.0	43.0	53.0	72.0	36.0	41.0	122.0	50.0	69.0	22.0	794.6	$14.18
	Quarts	1.0	7.3	8.4	9.5	4.2	7.0	10.0	14.0	23.5	14.0	44.5	21.5	26.5	36.0	18.0	20.5	61.0	25.0	34.5	11.0	397.3	
3	Pounds	1.8	18.8	18.8	18.3	6.5	14.5	14.0	21.0	47.5	34.0	64.0	44.0	41.0	58.0	24.0	41.5	97.0	70.0	76.0	24.0	734.7	13.12
	Quarts	0.9	9.4	9.4	9.2	3.3	7.3	7.0	10.5	23.8	17.0	32.0	22.0	20.5	29.0	12.0	20.8	48.5	35.0	38.0	12.0	367.4	
4	Pounds	1.0	6.5	13.8	16.0	9.0	16.5	17.0	31.0	47.0	30.0	51.0	32 0	40.5	48.0	37.0	73.0	118.0	51.0	62.0	23.0	723.3	13.19
	Quarts	0.5	3.3	6.9	8.0	4.5	8.3	8.5	15.5	23.5	15.0	25.5	16.0	20.3	24.0	18.5	36.5	59.0	25.5	31.0	11.5	361.7	
5	Pounds	0.5	14.0	14.0	22.5	10.0	17.0	28.0	28.0	53.0	16.0	63.0	34.0	30.0	57.0	21.0	57.0	145.0	40.0	65.0	18.0	733.0	13.77
	Quarts	0.3	7.0	7.0	11.3	5.0	8.5	14.0	14.0	26.5	8.0	31.5	17.0	15.0	28.5	10.5	28.5	72.5	20.0	32.5	9.0	366.5	
6	Pounds	0.3	2.5	4.5	8.0	6.5	6.5	15.0	18.0	33.0	22.0	38.0	30.0	37.0	34.0	20.0	80.0	78.0	94.0	58.0	26.0	611.3	10.15
	Quarts	0.2	1.3	2.3	4.0	3.3	3.3	7.5	9.0	16.5	11.0	19.0	15.0	18.5	17.0	10.0	40.00	39.0	47.0	29.0	13.0	305.7	
7	Pounds	0.8	6.5	10.0	17.5	12.0	16.3	31.0	34.0	59.0	38.0	62.0	43.0	39.0	62.0	30.0	100.0	100.3	73.0	49.0	17.0	800.4	14.75
	Quarts	0.4	3.3	5.0	8.8	6.0	8.2	15.5	17.0	29.5	19.0	31.0	21.5	19.5	31.0	15.0	50.0	50.2	36.5	24.5	8.5	400.2	
8	Pounds	0.3	6.8	8.3	25.0	9.0	8.1	23.0	35.0	50.0	29.5	58.5	76.0	40.0	51.0	27.5	107.5	109.5	57.0	50.0	36.0	808.0	14.33
	Quarts	0.2	3.4	4.2	12.5	4.5	4.0	11.5	17.5	25.0	14.8	29.3	38.0	20.0	25.5	13.8	53.8	54.8	28.5	25.0	18.0	404.0	
9	Pounds	......	4.5	8.5	14.0	8.0	8.3	21.0	24.0	42.0	31.0	51.0	23.0	27.0	46.0	35.0	57.0	97.0	76.0	92.0	27.0	692.3	11.77
	Quarts	......	2.3	4.3	7.0	4.0	4.2	10.5	12.0	21.0	15.5	25.5	11.5	13.5	23.0	17.5	28 5	48.5	38.0	46.0	13.5	346.2	

TABLE 1—Continued.

Yield and Selling Price of Tomatoes at Different Pickings.

NUMBER OF PLOT.		July 5.	July 8.	July 10.	July 12.	July 14.	July 15.	July 17.	July 19.	July 21.	July 22.	July 24.	July 25.	July 27.	July 29.	July 31.	August 2.	August 3.	August 5.	August 7.	August 9.	Total Yield per Plot.	Total Value per Plot.
10	Pounds	2.0	8.0	10.3	20.0	7.8	11.0	18.0	33.0	39.0	33.0	51.5	31.0	43.0	58 0	21.0	48.0	113.0	88.0	23.0	40.0	698.6	$12.46
	Quarts	1.0	4.0	5.2	10.0	3.9	5.5	9.0	16.5	19.5	16.5	25.8	15.5	21.5	29.0	10.5	24.0	56.5	44.0	11.5	20.0	349.3	
11	Pounds	1.8	14.0	12.5	18.0	8.0	13.0	17.0	29.0	36.0	16.0	79.0	32.0	40.0	26.0	27.0	28.0	90.0	67.0	49.0	25.0	628.3	11.29
	Quarts	0.9	7.0	6.3	9.0	4.0	6.5	8.5	14.5	18.0	8.0	39.5	16 0	20.0	13.0	13.5	14.0	45.0	33.5	24.5	12.5	314.2	
12	Pounds	0.5	2.5	8 0	8.0	3.0	3.5	6.0	13.0	18.0	15.0	23.0	16.0	16.0	25.0	17.0	18.0	46.0	45.0	64.0	30.0	377.5	6.04
	Quarts	0.3	1.3	4.0	4.0	1.5	1.8	3.0	6.5	9.0	7.5	11.5	8.0	8.0	12.5	8.5	9.0	23.0	22.5	32.0	15.0	188.8	
Selling Price per Basket		$2.00	$1 25	$1.15	$1.20	$1.50	$1.25	$0.90	$0.60	$0.55	$0.45	$0.30	$0.35	$0.40	$0.45	$0.65	$0.60	$0.50	$0.35	$0.25	$0.20	....	....
Selling Price per Pound		cts. 6.9	cts. 4.3	cts. 4.0	cts. 4.1	cts. 5.1	cts. 4.3	cts. 3.1	cts. 2.1	cts. 1.9	cts. 1.6	cts. 1.0	cts. 1.2	cts. 1.4	cts. 1.6	cts. 2.2	cts. 2.1	cts. 1.7	cts. 1.2	cts. 0.9	cts. 0.7	....	....
Total Value of Crop.		$0.93	$4.78	$5.50	$8.09	$4 98	$5.82	$6.85	$6 53	$9.87	$5.40	$6.94	$5.53	$6.36	$10.37	$7.38	$14.68	$19.92	$9.14	$6.77	$2.16	....	148.00

The weather was good until the first of July, when it became very dry and so continued throughout the month; on the 26th and 27th the weather was very hot, causing considerable loss by blistering both the ripe and green fruit. Prices throughout the early season, owing to the dry weather, were better than usual. Prices dropped to thirty cents on July 24th, though they picked up again on July 27th, and continued good until the 5th of August. Those picked up to July 22d, inclusive, are considered as early tomatoes, since one object of the test is to determine whether nitrate of soda, either alone or in connection with other fertilizing elements, in any way influences maturity.

Table 2 has been prepared to show what per cent. of the whole yield was early tomatoes, and also what per cent. of the total money value of the whole crop was represented by the money value of that yield. It permits a consideration of—

1. The yield at selling prices above the average price secured for the whole crop.

2. The relation of the value of that yield to the value of the entire yield.

TABLE 2.

The Relation of the Yield and Value of Early Tomatoes to the Total Yield and Total Value of Crop.

Number of Plot.	Total Yield in Pounds per Plot.	Yield in Pounds per Plot Sold at Prices Ranging from 45 cts. to $2 per Basket.	Per cent. of the Whole Yield per Plot Sold at Prices Ranging from 45 cts. to $2 per Basket.	Total Value of Yield per Plot.	Value of Yield per Plot Sold at Prices Ranging from 45 cts. to $2 per Basket.	Per cent. of Total Value of Yield per Plot Sold at Prices Ranging from 45 cts. to $2 per Basket.
1	....	....	....	....	....	....
2	794.6	197.6	24.9	$14.18	$5.79	40.8
3	734.7	195.2	26.6	13.12	5.71	43.5
4	723.3	187.8	26.0	13.19	5.28	40.0
5	733.0	203.0	27.7	13.77	6.08	44.1
6	611.3	116.3	19.0	10.15	3.07	30.2
7	800.4	225.1	28.1	14.75	6.17	41.8
8	808.0	195.0	24.1	14.33	5.35	37.3
9	692.3	161.3	23.3	11.77	4.32	36.7
10	698.6	182.1	26.1	12.46	5.11	41.0
11	628.3	165.3	26.3	11.29	5.01	44.4
12	377.5	77.5	20.5	6.04	2.14	35.4

The yield of early tomatoes was very largely increased by the use of nitrate, though its use alone was more beneficial than when in combination with minerals. An increase in yield is also observed from the use of minerals alone, though much less than from the use of nitrates, or even barnyard manure. The proportionate increase in yield from the use of manures is much greater than in any previous experiment. Using the yield on the unfertilized land on plot 12 as a basis of comparison, it is shown that nitrate of soda decidedly influenced maturity. Where nitrate was used alone, maturity seems to have been influenced favorably by the second application, while when used in connection with minerals the results from fractional applications are not uniform. The percentage yield of early tomatoes on plot 12 is 20.5; the average of the four plots treated with nitrate alone is 26.3 per cent., and of the four plots with nitrate in connec-

tion with minerals, 25.4. The percentage from the barnyard manure plots is identical with that of nitrate alone, while from minerals alone the percentage is 19, or lower than on the unmanured land.

These results are in accord with the teachings of previous experiments, except in the case of minerals alone, which are the reverse of those previously recorded.

Since the results do not seem to have been uniformly influenced by fractional applications of nitrate of soda, the results may be properly studied in groups of two plots each. No. 1, including plots 2 and 3, with an equivalent of 160 pounds per acre of nitrate of soda alone; No. 2, plots 7 and 8, with 160 pounds of nitrate in connection with minerals; No. 3, plots 4 and 5, with 320 pounds of nitrate alone; and No. 4, plots 9 and 10, with 320 pounds of nitrate in connection with minerals.

In Table 3 the results are arranged in the order stated, and may be compared with each other and with those from the use of minerals alone and from barnyard manure.

TABLE 3.

	Kind and Amount of Fertilizer per Acre.	Yield of Early Tomatoes.	Per cent. of Total Yield.	Value of Early Tomatoes.	Per Cent. of Total Value.
Unfertilized Plot......	....	77.5	20.5	$2.14	35.4
Group 1..................	160 lbs. Nitrate.........	196.4	25.8	5.75	42.2
" 2..................	160 " Nitrate...... 320 " Bone Black 160 " Muriate.....	210.1	26.0	5.76	39.6
" 3..................	320 " Nitrate.........	195.4	26.9	5.68	42.1
" 4..................	320 " Nitrate...... 320 " Bone Black 160 " Muriate.....	171.7	24.7	4.72	38.9
Minerals alone.........	320 " Bone Black 160 " Muriate.....	116.3	19.0	3.07	30.2
Barnyard Manure.....	20 tons....................	165.3	26.3	5.01	44.4

The yield of early tomatoes was very decidedly increased by the use of nitrate of soda, both alone and together with phosphoric acid and potash. Maturity was increased in every case—that is, the yield of early tomatoes was proportionately greater in all the groups than upon the unfertilized plot. The greatest increase in maturity was in group 3, from the heavy applications of nitrate, while the average maturity for all the plots treated with nitrate was 5.4 per cent. greater than on the unfertilized plot. Barnyard manure stands next to group 3 and is slightly above the average of the nitrated plots.

These results on maturity, from the standpoint of proportionate yield of early tomatoes, are in accord with those secured in 1892 On the basis of actual value of early tomatoes, however, the true basis of comparison, the results are in favor of groups 1 and 2, with small quantities of nitrate of soda, either alone or in connection with minerals. The average of five years still showing the best results from the use of the small quantities of nitrate alone.

The value per acre of the increased yield of early tomatoes for 1889, 1890, 1891, 1892, 1893, and an average of the five years, due to the methods of fertilization ruling in the experiments, is included in the following table:

	1889.	1890.	1891.	1892.	1893.	Average of Five Years.
Group 1	$59.80	$28.80	$79.60	$35.40	$72.20	$55.16
" 2	55.40	12.80	60.20	40.80	72.40	48.32
" 3	51.20	17.80	37.80	50.80	70.80	45.68
" 4	47.00	9.80	10.00	33.00	51.60	30.28
Minerals alone	32.40	2.80	61.20	34.20	18.60	29.84
Barnyard Manure	11.80	21.40	16.40	44.00	57.40	30.20

This tabulated statement of the value per acre of the increased yield of early tomatoes for five years, on different soils and in different seasons, is valuable, first, in showing that under the varying conditions of soil, season and manure an increased value was secured in every case, and that the average increase for the five years was decidedly profitable; and second, that with one exception—1892—the largest increased value each year was secured from the use of 160 pounds of nitrate of soda per acre, and that the average increase for the five years from the use of nitrate of soda was $6.84 greater than from any method of manuring with nitrate, and about $25 greater than from the use of the mineral constituents, phosphoric acid and potash, or from the use of large quantities of barnyard manure. This statement, of course, simply gives the actual money value of the

increased yield for each season, and for the average of five seasons, without reference to profit or loss.

Considered from the standpoint of the relation of increased value of crop to cost of the material producing it, the practical value of these results becomes apparent, which the accompanying tabulation shows:

	Average Value of Increased Yield.	Average Cost of Fertilizer.	Average Net Value.
Group 1	$55.16	$4.00	$51.16
" 2	48.32	11.20	37.12
" 3	45.68	8.00	37.68
" 4	30.28	15.20	15.08
Minerals alone	29.84	7.20	22.64
Barnyard Manure	30.20	30.00	.20

These figures are significant, especially when it is remembered that the yield represented refers entirely to early tomatoes, and is less than one-half of the total.

A careful study of this work should materially change the practice, now so prevalent, of using large quantities of barnyard manure only, though the specific practice adopted should follow a careful study of soil conditions, hence the statement made in previous reports, as to methods of manuring tomatoes, will bear repeating, as having been verified for five years in carefully-conducted experiments, on soils differing both in physical character and chemical properties, and including a wide variety of seasons:

"It must not be supposed that on soils differing in character, and under the varying conditions of fertility and season, nitrate of soda alone would always be the most profitable fertilizer, for the presence of the mineral elements, phosphoric acid and potash, is quite as essential for the full growth and development of this crop as nitrogen. Yet where the land has received good treatment and previous liberal manuring, and is reasonably adapted to this crop, the direct application of the mineral elements, while perhaps producing a greater vigor of growth and a consequently larger total crop, does seem to retard proportionate maturity. Therefore, under these conditions, nitrate of soda used alone in small quantities would give the best and most profitable results. Since these experiments have been in progress, many practical farmers have reported that such fertilization has been uniformly satisfactory."

The previous discussion has had reference to the yield and value of early tomatoes, the main object when grown for the general market.

In the subsequent discussion the conditions governing highest yield and value will be considered :

TABLE 4.

Yield and Value of Crop per Acre Calculated to Full Stand.

Number of Plot.	Actual Yield.		Yield Calculated to Full Stand.		Average Selling Price per Basket.	Value of Crop Calculated to Full Stand.
	Number of Plants.	Baskets.	Number of Plants.	Baskets.		
1	....	....	....	....	....	....
2	2,680	548	2,720	556	51.8	$288.01
3	2.700	507	"	511	51.8	264.70
4	2,700	499	"	503	52.9	266.09
5	2,720	506	"	506	54.9	277.79
6	2,720	422	"	422	48.1	202.98
7	2,700	552	"	556	53.4	296.90
8	2,720	557	"	557	51.5	286.86
9	2,680	477	"	484	49.4	239.10
10	2,560	482	"	512	51.7	264 70
11	2,660	433	"	443	52.1	230.80
12	2,640	260	"	268	46.5	124.62

In the above table the actual yields and yield calculated to full stand are recorded. The valuations are based upon full stand. There were few plants lost on any of the plots, and in making the calculations it was assumed that the yield and value of the total product of full stand would have been proportionately the same as ruled for the actual product secured. The variations in weight per basket of tomatoes from the different plots, while noticeable, were too small to be taken into consideration. The average weight per basket of 15 quarts was 29 pounds.

The yield on the unmanured land was somewhat less than in any other experiment on this farm, though it is believed to fairly represent the natural productiveness of the land. A large increase in yield was secured on all the manured plots. The range in yield from the unmanured plot—268 baskets—to the highest—557 baskets, on plot 8—is 289 baskets, or an increase of 107.8 per cent. The yield on the nitrated plots ranges from 484 baskets on plot 9, to 557 on plot 8, or 73 baskets. The average increased yield from the use of nitrate alone is 247 baskets, and from nitrate in connection with minerals is 259 baskets. Barnyard manure and minerals alone on plots 6 and 11 were also effective in increasing total yield, though very much less effective than any of the methods of nitrate-manuring.

The effect of different quantities and different methods of application of nitrate of soda upon yield per acre is indicated in detail in the following comparisons:

Comparison of Average Increased Yields.

Yield from unfertilized land	268	baskets.
Increased yield due to mineral elements alone	154	"
" " " " twenty loads of barnyard manure	175	"
Average increased yield due to nitrate of soda alone	241	"
" " " " " " " " with minerals	259	"

Variations in Increased Yield Due to Different Methods of Application of Nitrate of Soda.

ALONE.			WITH ADDITION OF MINERALS.		
160 pounds in one application	288	baskets.	160 pounds in one application	288	baskets.
160 " " two applications	243	"	160 " " two applications	289	"
Gain from one application	45	"	Gain from two applications	1	"
320 pounds in one application	235	"	320 pounds in one application	216	"
320 " " two applications	238	"	320 " " two applications	244	"
Gain from two applications	3	"	Gain from two applications	28	"

Variations in Increased Yield Due to Different Quantities of Nitrate of Soda.

ALONE.			WITH ADDITION OF MINERALS.		
160 pounds in one application	288	baskets.	160 pounds in one application	288	baskets.
320 " " " "	235	"	320 " " " "	216	"
Gain from smaller	53	"	Gain from smaller	72	"
160 pounds in two applications	243	"	160 pounds in two applications	289	"
320 " " " "	238	"	320 " " " "	244	"
Gain from smaller	5	"	Gain from smaller	45	"

A study of this table shows that nitrate of soda in connection with minerals was more effective than any other method of manuring, and that nitrate of soda alone was more useful than barnyard manure or the minerals alone. It is also shown that fractional applications of nitrate were effective in increasing yield in three out of four cases, though the increase was but nominal in two cases. In reference to the quantity of nitrate it is shown that the smaller quantity—160 pounds per acre—was this year more useful than the larger quantity —320 pounds per acre. On the same basis of comparison, the results for five years, including twenty comparisons, show that the fractional or second application of nitrate was more effective in increasing total yield in 13 cases, and the single application in 6 cases; the larger application being more effective in 11 cases, and the smaller quantity in 9 cases. On the whole, therefore, fractional applications of larger quantities of nitrates may reasonably be expected to give the largest yields.

As before stated, experiments similar in plan to the one reported were carried out in 1889, 1890, 1891 and 1892, under conditions of soil considered favorable for the crop, and the management of which conformed to the practice of the best growers. The results secured in the different experiments agree in several important particulars, making it possible to average the results and study them as a whole.

In order to make the comparison for the different years uniform, the yield on the unfertilized land is represented by 100 baskets, and the data in the following table are secured from calculations made on that basis:

TABLE 5.

Number of Plot.	YIELD CALCULATED ON THE BASIS THAT THE YIELD ON UNFERTILIZED PLOTS EQUALS 100.					
	1889.	1890.	1891.	1892.	1893.	Average for Five Years.
1	100	100	100	100	100	100
2	133	133	154	142	207	154
3	139	152	153	139	191	155
4	132	151	177	150	188	160
5	136	142	169	163	189	160
6	105	121	120	131	157	127
7	131	126	160	159	207	157
8	154	138	161	140	208	160
9	145	149	161	149	181	157
10	158	147	159	147	191	161
11	107	120	113	153	165	132
12	100	100	100	100	100	100

Observing the same methods of comparison, the average results stand as follows; the increase in each case, though stated in terms of baskets, shows the percentage increase:

Comparison of Average Increased Yields.

Increased yield due to mineral elements alone	27	baskets.
" " " " barnyard manure alone	32	"
Average increased yield due to nitrate of soda alone	57	"
" " " " " " " " with minerals	59	"

Variations in Increased Yield Due to Different Methods of Application of Nitrate of Soda.

ALONE.

160 pounds in one application	54	baskets.
160 " " two applications	55	"
Gain from two applications	1	basket.
320 pounds in one application	60	baskets.
320 " " two applications	60	"
No gain.		

WITH ADDITION OF MINERALS.

160 pounds in one application	57	baskets.
160 " " two applications	60	"
Gain from two applications	3	"
320 pounds in one application	57	"
330 " " two applications	61	"
Gain from two applications	4	"

Variations in Increased Yield Due to Different Quantities of Nitrate of Soda.

ALONE.		WITH ADDITION OF MINERALS.	
160 pounds in one application	54 baskets.	160 pounds in one application	57 baskets.
320 " " " "	60 "	320 " " " "	57 "
Gain from larger	6 "	No gain.	
160 pounds in two applications	55 "	160 pounds in two applications	60 "
320 " " " "	60 "	320 " " " "	61 "
Gain from larger	5 "	Gain from larger	1 basket.

These results, the average of five experiments, confirm in nearly every particular the conclusions arrived at from studies from other standpoints as well as the conclusions derived from individual experiments, showing that as a fertilizer for tomatoes—

1. Nitrate of soda is superior to both barnyard manure and mineral fertilizers alone.
2. Nitrate of soda alone is on the whole but slightly less effective than the complete manure.
3. When small quantities of nitrate are used, the second application is advantageous; and
4. Large quantities (320 pounds per acre) of nitrate are more effective than small quantities (160 pounds per acre).

The cost of handling and marketing a crop of course varies according to the circumstances of the farmer and his location in reference to markets. The practically uniform condition is the cost of fertilizers; deducting this cost we have the value of the crops on the different plots reduced to a uniform basis. The net value, therefore, means simply the total value less the cost of fertilizer, and not the price actually received for the crop.

TABLE 6.

Number of Plot.	Fertilizer. Kind.	Fertilizer. Quantity per Acre.	Cost of Fertilizer per Acre.	Yield in Baskets per Acre.	Total Value of Crop per Acre.	Net Value of Crop per Acre.	Net Value of Increased Yield.	Average Net Results for 5 Years, 100 Representing Average Value of Yield of Unfertilized Land.
1	Unfertilized	....	....	....	....	....	....	....
2	Nitrate of Soda	160 lbs.	$4.00	556	288.01	284.01	$159.39	159
3	Nitrate of Soda	160 "	4.00	511	264.70	260.70	136.08	155
4	Nitrate of Soda	320 "	8.00	503	266.09	258.09	133.47	153
5	Nitrate of Soda	320 "	8.00	506	277.79	269.79	145.17	162
6	Superphosphate .... Muriate of Potash	320 " 160 "	7.20	422	202.98	195.78	71.16	128
7	Nitrate of Soda .... Superphosphate .... Muriate of Potash	160 " 320 " 160 "	11.20	556	296.90	285.70	161.08	157
8	Nitrate of Soda .... Superphosphate .... Muriate of Potash	160 " 320 " 160 "	11.20	557	286.86	275.66	151.04	156
9	Nitrate of Soda .... Superphosphate .... Muriate of Potash.	320 " 320 " 160 "	15.20	484	239.10	223.90	99.28	140
10	Nitrate of Soda .... Superphosphate .... Muriate or Potash	320 " 320 " 160 "	15.20	512	264.70	249.50	124.88	151
11	Barnyard Manure	20 tons.	30.00	443	230.80	200.80	76.18	119
12	Unfertilized	....	....	268	124.62	124.62	....	100

The net value of the crop on the unmanured land is $124 62. The highest net value of crop—$285.70—was secured on plot 7, an increase of $161.08 from the most effective use of nitrate of soda.

Comparison of Average Net Value of Crops.

	Average Net Value of Crop.	Increased Value.
Unfertilized plot	$124.62	....
Minerals alone	195.78	$71.16
Barnyard manure	200.80	76.18
Nitrate of soda alone.	268.15	143.53
" " " with minerals	258.69	134.07

The results this year and the average results for the four years may be grouped as follows, 100 being the basis of comparison—that is, the net value of the crop on the unfertilized land is represented by 100:

Comparison of Net Gains due to Different Quantities of Nitrate of Soda.

	1893.	Average of Five Years.
	Per cent.	Per cent.
160 pounds of nitrate of soda alone, costing $4, gave	118.6 increase.	57.3 increase.
320 " " " " " " " $8, "	111.8 "	57.6 "
160 " " " " " with minerals, costing $11.20, gave..	125.2 "	56.6 "
320 " " " " " " " " $15.20, " ..	89.9 "	45.6 "

The net gain this year is greatest from small quantities of nitrate of soda in connection with minerals, and least from large quantities in connection with minerals; the latter result is identical with that secured in 1892, though in that year the large quantity of nitrate alone gave the greatest net gain. The average percentage increase for five years shows that there is practically but little difference in net results secured from small or large quantities used alone, and from small quantities used with minerals, but that when large quantities (320 pounds per acre) are used with minerals, the financial results, while reasonably large, are much less satisfactory than when the other methods of use are practiced. The results secured in 1889 have been verified in the most important particulars in 1890, 1891, 1892 and 1893, thus giving much light as to methods of manuring, whether grown for the general market or for the canneries.

It is one of the most important of our crops, and the suggestions given by these experiments should be carefully studied, in order that they may be properly applied to the varying conditions that necessarily exist. In a general way the following methods of manuring may, it is believed, be followed with profit:

1. Where land has been heavily fertilized or manured for the previous crop, apply evenly over the row from 200 to 300 pounds of nitrate of soda per acre, one-half at time of setting the plants and the remainder from three to four weeks later.

2. Where the land is light and has not been heavily manured, apply broadcast and harrow into the soil before setting the plants 500 pounds per acre of a mixture made up of two parts of bone-black superphosphate and one part of muriate of potash, and 150 to 250 pounds of nitrate of soda in the same manner as suggested above.

2.

EXPERIMENTS WITH FERTILIZERS UPON WHITE POTATOES.

These experiments were conducted on a plan similar to that reported in 1892, the object of which was to test the effect of different methods of manuring, and of the effect of the different forms of potash salts upon the yield and quality of the potato.

LOCATION OF EXPERIMENTS AND DESCRIPTION OF SOILS.

Two experiments were carried out, one upon the farm of David T. Brown, of Mickleton, Gloucester county, and the other upon the farm of S. S. Voorhees, of Mine Brook, Somerset county.

The farm of Mr. Brown consists of a sandy loam, with a porous, clayey subsoil. The experiment plot was level, well drained, of medium fertility and reasonably well adapted for early potatoes, which is an important crop in that section of the State. All conditions of preparation of soil, cultivation and management of crop, conformed to the best methods in use there.

The crops grown and methods of manuring on this farm are corn, sweet potatoes, white potatoes, melons and hay. New York or Philadelphia horse manure is used almost altogether and in considerable quantities upon potatoes and melons; the corn and hay are not manured.

The land under experiment upon the farm of Mr. Voorhees is a gravelly clay loam, with porous yellow clay subsoil and good natural drainage. The crops grown are chiefly grain and hay. The crops and manures for the six years preceding the experiments are as follows: 1887, wheat, yield 20 bushels per acre, dressed with small amounts of yard manure and fertilizers; 1888, clover and timothy hay, yield $1\frac{1}{2}$ tons per acre; 1889 and 1890, timothy, yield $1\frac{1}{4}$ and 2 tons per acre respectively; 1891, pasture; 1892, corn, yield 35 bushels per acre—about half the usual crop, owing to serious injury by insects. The land received 10 tons of manure per acre in the fall of 1889 and 1891. Potatoes have not been grown to any extent upon the farm, though well adapted for the crop, particularly late varieties.

Each experiment occupied fourteen plots, each one-twentieth of an acre in area. The plots were long and narrow, the widest admitting three rows per plot.

The land was carefully prepared in all the experimental areas, and the crop thoroughly cultivated.

Mr. Brown planted in the latter part of March, and Mr. Voorhees on May 3d.

In both experiments the potatoes came up well and made a rapid growth of vine. The Early Rose was planted by Mr. Brown, and the Maine Rose by Mr. Voorhees.

The weather in the early season was wet, followed by very dry weather in June and July, which made the growth uneven and materially reduced the setting, particularly in the experiment of Mr. Voorhees. Mr. Brown reported on June 17th "that the plants on plots 2 and 4 were much the poorest of the fertilized plots, and that 6, 12 and 13 were the best, and quite uniform in appearance; plots 9, 10 and 11, were uniform in size and but little behind 6, 12 and 13; and 7 and 8, slightly better than 3 and 5, and all poorer than 9, 10 and 11. The vines on plots 1 and 14 were much smaller than on any of the manured or fertilized plots." The same order prevailed when the experiment was visited by a Station officer on July 10th.

This report is interesting in that it agrees so closely with the actual results secured when the crop was harvested.

The experiment of Mr. Voorhees was visited May 30th, when but little difference could be observed in the fertilized and manured plots, which were better than 1 and 14. The experiment of Mr. Brown was harvested July 25th, and that of Mr. Voorhees, September 20th. The potatoes in both cases were exceptionally fine both as to size and uniformity, though the yields were not large, owing to the relatively small number of tubers.

CONSIDERATION OF YIELD.

The accompanying table shows the amount and kind of fertilizer used and the yield per plot:

TABLE 1.

Number of Plot.	KIND OF FERTILIZER.	Quantity per Plot.	David T. Brown. POUNDS PER PLOT. Large.	Small.	Total.	Samuel S. Voorhees. POUNDS PER PLOT. Large.	Small.	Total.
1	Unfertilized		146	34	180	180	30	210
2	Bone Black Muriate of Potash	16 lbs. 8 "	257	37	294	270	90	360
3	Bone Black Muriate of Potash Nitrate of Soda	16 " 8 " 10 "	305	39	344	270	60	330
4	Bone Black Sulphate of Potash	16 " 8 "	235	47	282	330	45	375
5	Bone Black Sulphate of Potash Nitrate of Soda	16 " 8 " 10 "	321	32	353	420	34	454
6	Barnyard Manure	1 ton.	395	43	438	300	34	334
7	Bone Black Muriate of Potash Nitrate of Soda	16 lbs. 8 " 10 "	343	34	377	375	44	419
8	Bone Black Sulphate of Potash Nitrate of Soda	16 " 8 " 10 "	339	42	381	413	45	458
9	Barnyard Manure Bone Black Muriate of Potash Nitrate of Soda	½ ton. 8 lbs. 4 " 5 "	428	38	466	360	38	398
10	Bone Black Muriate of Potash Nitrate of Soda	24 " 12 " 15 "	393	36	429	375	53	428
11	Bone Black Sulphate of Potash Nitrate of Soda	24 " 12 " 15 "	371	36	407	480	34	514
12	Barnyard Manure	1 ton.	493	46	539	330	45	375
13	Barnyard Manure Bone Black Muriate of Potash Nitrate of Soda	1 " 16 lbs. 8 " 10 "	563	29	592	323	38	361
14	Unfertilized		106	32	138	255	49	304

In order to test the uniformity and productiveness of the natural soil, two plots in each experiment were not fertilized. The variations in the yields of the unfertilized plots are considerable; the yields upon duplicate plots—both manured and fertilized—also show wide variations. These results are believed to be due more to conditions of season than to variations in the character of the soil. The experi-

ments, however, are of considerable interest in showing, first, that the yields of both the manured and fertilized plots are much greater than the highest yield from the unfertilized land, and second, that the proportion of unmerchantable tubers is largely decreased on the fertilized plots. In the experiment of Mr. Brown the unmerchantable potatoes on the unmanured land was over 20 per cent. of the whole, while the average of the other plots showed less than 10 per cent.

In the experiment of Mr. Voorhees, the percentage of small potatoes on the unmanured land was over 15 per cent., while on the manured land it was less than 12 per cent.

In the following table, the results are expressed in bushels per acre of merchantable potatoes, no account being taken of the small tubers. Commercial values are also included in order that comparison may be made on that basis, the price per bushel being fixed at seventy-five cents, the ruling price at time of digging. The actual cost of manures is also stated in all cases, which, deducted from the total value of crop, shows the net value:

TABLE 2.

Number of Plot.	Cost of Fertilizer per Acre.	Bushels of Merchantable Potatoes per Acre.		Total Value of Crop per Acre.		Net Value of Crop per Acre.		Net Gain or Loss per Acre.	
		D. T. Brown. Experiment 1.	S. S. Voorhees. Experiment 2.	Experiment 1.	Experiment 2.	Experiment 1.	Experiment 2.	Experiment 1.	Experiment 2.
1	....	48.7	60.0	$36.52	$45.00	$36.52	$45.00	....	....
2	$7.70	85.7	90.0	64.28	67.50	56.58	59.80	$25.08	$5.42
3	12.34	101.7	90.0	76.28	67.50	63.94	55.16	32.44	0.78
4	8.90	78.3	110.0	58.73	82.50	49.83	73.60	18.33	19.22
5	13.54	107.0	140.0	80.25	105.00	66.71	91.46	35.21	37.08
6	40.00	131.7	100.0	98.78	75.00	58.78	35.00	27.28	—19.38
7	12.34	114.3	125.0	85.73	93.75	73.39	81.41	41.89	27.03
8	13.54	113.0	137.7	84.75	103.28	71.21	89.74	39.71	35.36
9	26.17	142.7	120.0	107.03	90.00	80.86	63.83	49.36	9.45
10	18.51	131.0	125.0	98.25	93.75	79.74	75.24	48.24	20.86
11	20.31	123.7	160.0	92.78	120.00	72.47	99.69	40.97	45.31
12	40.00	164.3	110.0	123.23	82.50	83.23	42.50	51.73	—11.88
13	52.34	187.7	107.7	140.78	80.78	88.44	28.44	56.94	—25.94
14	....	35.3	85.0	26.48	63.75	26.48	63.75	....	....

As already intimated in the discussion of yields, the variations are so great as to render it impossible to draw more than a general lesson from the results this year, and a study of the financial results shows that this lies in a comparison of different methods of manuring.

Plots 3, 5, 7 and 8 were fertilized with a complete manure, containing in each case amounts of plant-food equivalent to 32 pounds of nitrogen, 52 pounds of phosphoric acid, and 80 pounds of actual potash per acre; on 10 and 11 these amounts of plant-food were increased by 50 cent. Plots 9 and 13 received both stable manure and chemical manures, while plots 6 and 12 received stable manure alone.

		Experiment 1.		Experiment 2.	
	Cost of Fertilizer.	Net Value of Crop.	Net Value of Incr'd Crop.	Net Value of Crop.	Net Value of Incr'd Crop.
Unfertilized	....	$31.50	....	$54.38	....
Stable manure alone	$40.00	71.01	$39.51	38.75	—$15.63
Stable manure and chemical manure	39.26	84.65	53.15	46.14	—8.24
Complete chemical manures alone	15.10	71.24	39.74	82.12	27.74

In experiment No. 1 all methods of manuring were profitable; the best results were secured from a combination of stable manure and chemical manures, the net value of increased crop reaching $53.15 per acre, the results from stable manure alone and chemical manures alone being practically identical, the net value of increased crop reaching $39.51 per acre for the former, and $39.74 per acre for the latter. In experiment No. 2 the only method that proved financially favorable was the use of chemical manures alone, though the net value of increased crop in this case was much lower than in any case in experiment No. 1. The increased yield from manures and chemicals was sufficient to pay three-quarters of the cost of the manures, while the increased value of crop, due to stable manure alone, was but $24.37, or about 60 per cent. of the cost of the manures.

These experiments, though unsatisfactory in many respects, do teach one very important lesson, viz., *that under circumstances which require the buying of manures, if they are used at all, it pays to carefully consider their relative cost.*

Owing to the lack of uniformity in yield, samples from the various plots were not subjected to chemical analyses.

3.

EXPERIMENTS WITH FERTILIZERS UPON SWEET POTATOES.

BY THEODORE BROWN, SWEDESBORO, GLOUCESTER COUNTY.

The results of experiments with fertilizers upon sweet potatoes last year indicated the following general conclusions:

1. That profitable crops can be raised with chemical manures alone, and that the net profits of the crop are greater than from New York horse manure alone.
2. That organic forms of nitrogen, as dried blood, are more useful than nitrate of soda.
3. That combinations of chemical and horse manures are more satisfactory than horse manure alone.

The following description of the present general practice of growing sweet potatoes in this State is quoted from the annual reports of 1891–92, though the section in reference to manures is not so true as when first stated; many are gradually changing from horse manure alone to horse manure in connection with chemical manure, or chemical manure alone:

"Two methods are followed in regard to the setting of plants in the field, one in which the plants are set in hills two and one-half feet each way, the other in which they are grown in drills eighteen inches by two and one-half feet. In very few instances can satisfactory crops be grown without liberal manuring. Many growers claim that barnyard manure is the best form to use, while a few affirm that the crop cannot be profitably grown with any other.

"The general custom is to use from eight to ten tons per acre broadcast, and an equal amount in the hill or row at the time of setting the plants. The manure used is chiefly New York horse manure, which this year costs $2 per ton at the consumer's depot. It is usually carted during the fall and winter and placed in the field in heaps of from twenty to thirty tons and covered lightly with soil. In the spring it is repeatedly worked over, in order to make it very fine before applying in the hills. It is quite likely, notwithstanding the admixture of a small amount of soil, that one ton, when applied, represents more than one ton at time of buying, owing to loss in weight from decay and evaporation.

"When grown in hills, 220 bushels of large potatoes per acre is considered a good yield; when grown in drills, 250 bushels per acre is nearer the average; 300 bushels per acre is a good crop, though very much larger yields are frequently obtained."

New York or Philadelphia horse manure is, however, still the main stand-by for the crop. The amounts required, added to the labor of handling so bulky a product, make the crop an expensive one to raise. Hence the object of the experiment was—

First. To learn whether profitable crops could be raised with chemical manures alone;

Second. To study the comparative effect of nitrogen in the form of nitrate of soda or of dried blood;

Third. To study the comparative effects of different quantities of New York horse manure alone and in combination with chemical manures.

LOCATION OF EXPERIMENT AND DESCRIPTION OF SOIL.

The experiment was again carried out on the farm of Mr. Theodore Brown, of Swedesboro, Gloucester county.

The soil on the farm of Mr. Brown is a sandy loam, in good state of fertility and well adapted to sweet potatoes. The whole area under experiment was 70 x 436 feet, or 5 x 436 feet for each plot. The land sloped slightly though uniformly towards the south. The land under experiment had been cropped and fertilized in former years as follows: In 1890, clover and timothy hay, followed by ruta-bagas, with 500 pounds of Swift-sure superphosphate per acre; in 1891, corn, with no fertilizer; in 1892, sweet potatoes, fertilized with 18 tons of New York horse manure per acre, one-half in hill, one-half broadcast, and 200 pounds of muriate of potash per acre, broad-cast, early in the spring.

FIELD RECORD.

The land was plowed early in March; the rows were marked two and one-half feet apart and the fertilizer applied in the row and covered with corn-coverer May 5th. The drills were plowed up on May 15th. The setting of plants began May 16th. The setting was done across the plots, 18 inches apart in the row, though owing to

rain in the afternoon, and cold and wind following the rain, the remainder of the plants were not set until the afternoon of the 20th; the weather following the last setting was favorable for a good stand. Mr. Brown reports on June 23d "that while there was no marked difference in the plants, those set May 20th were larger and more vigorous than those set on the 16th, and that the latter were more susceptible to the attacks of the flea beetle. The experiment was visited on July 10th, when the vines on plots 1 and 14 were smaller and lighter in color than those on the remainder of the plots; no appreciable difference was noted in the plants set at different dates. The season was not regarded as favorable for this crop, owing to the drouth in July.

The accompanying table shows the number of plots, the amount and kind of fertilizer used and the yield per acre, calculated in bushels, using the legal standard of 54 pounds per bushel. The experiment contained 14 plots, each one-twentieth of an acre in area. In the plan adopted five plots were treated in duplicate, viz., 1 and 14, unfertilized; 2 and 6, with the mineral elements, phosphoric acid and potash; 3 and 8, with the mineral elements in connection with nitrogen in the form of nitrate of soda; 4 and 9, with minerals in connection with nitrogen in the form of dried blood; and 5 and 10, with New York horse manure alone; 11 and 12 received the same kind of plant-food as plots 3 and 4 respectively, though in larger quantities, while 7 and 13 were treated with New York horse manure and chemicals in different quantities.

TABLE 1.

Number of Plot.	FERTILIZER. Kind.	FERTILIZER. Quantity per Acre.	BUSHELS PER ACRE. Large.	BUSHELS PER ACRE. Small.	BUSHELS PER ACRE. Total.
1	Unfertilized		111.9	70.0	181.9
2	Bone Black Muriate of Potash	320 lbs. 160 "	177.0	56.3	233.3
3	Bone Black Muriate of Potash Nitrate of Soda	320 " 160 " 200 "	175.6	57.0	232.6
4	Bone Black Muriate of Potash Dried Blood	320 " 160 " 280 "	141.1	51.9	193.0
5	Barnyard Manure	1 ton.	160.7	51.1	211.8
6	Bone Black Muriate of Potash	320 lbs. 160 "	164.1	73.0	237.1
7	Barnyard Manure Bone Black Muriate of Potash Nitrate of Soda	½ ton. 160 lbs. 80 " 100 "	167.8	54.8	222.6
8	Bone Black Muriate of Potash Nitrate of Soda	320 " 160 " 200 "	176.3	58.5	234.8
9	Bone Black Muriate of Potash Dried Blood	320 " 160 " 280 "	148.1	67.4	215.5
10	Barnyard Manure	1 ton.	181.1	57.4	238.5
11	Bone Black Muriate of Potash Nitrate of Soda	480 lbs. 240 " 300 "	155.9	60.7	216.6
12	Bone Black Muriate of Potash Dried Blood	480 " 240 " 420 "	143.3	57.4	200.7
13	Barnyard Manure Bone Black Muriate of Potash Nitrate of Soda	1 ton. 320 lbs. 160 " 200 "	171.1	50.0	221.1
14	Muriate of Potash	200 "	142.2	64.4	206.6

DISCUSSION OF YIELDS PER ACRE.

It was the intention to have two unfertilized plots, Nos. 1 and 14, but owing to a misunderstanding plot 14 received a dressing of muriate of potash at the rate of 200 pounds per acre, in common with the remainder of the field not under experiment. The land is, however, of a very uniform character, and its productiveness without manure is believed to be well represented by the yield on plot 1. The total yields per acre are much less this year than in 1892, which was expected, owing to the rather unfavorable season. The yield upon duplicate plots is, however, much more uniform than in 1892. In total yield the widest variation from the average—13 bushels per acre—occurs on the plots dressed with New York horse manure alone. The table shows the yield of both large and small potatoes; the following tabulation is arranged to show the relation of large to small roots, for the different methods of manuring, and a comparison of the per cent. of large for 1892 and 1893:

	Total. Bushels.	Large. Bushels.	Small. Bushels.	Per cent. Large, 1893.	Per cent. Large, 1892.	Average. Large For two years.
Group 1. Unfertilized	181.9	111.9	70.0	61.5	66.3	63.9
" 2. Minerals alone	235.2	170.6	64.6	72.5	70.5	71.5
" 3. Minerals and nitrate of soda	228.0	169.3	58.7	74.3	74.1	74.2
" 4. Minerals and dried blood	203.1	144.2	58.9	71.0	77.1	74.0
" 5. Barnyard manure	225.2	170.9	54.3	75.9	76.9	76.4

A study of this table shows that each method of manuring resulted in a considerable increase in crop, the yield from the average of all methods showing an increase of 41.9 bushels per acre. The average total yield from the chemical manures in groups 2, 3 and 4 was 222.9 bushels, or 40.2 bushels greater than from group 1; the yield from the horse manure was 225.2, or 43.3 bushels greater, thus showing a practical uniformity of yield by these methods when total yield alone is made the basis of comparison. The minerals alone were quite as effective as the minerals in connection with nitrate of soda, and more effective than when used in connection with the dried blood. The chemical manures in connection with New York horse manure were no more effective than the manure alone or the chemical manures. Increasing the chemical manures by 50 per cent. on plots 11 and 12 did not increase the yield.

While the different methods of manuring did not show marked differences in reference to total yield, the relation of large potatoes to total was materially influenced. On the unfertilized plots, 61.5 per cent. of the total yield was "firsts." This was increased by 11 per cent. from minerals alone; by 12.8 per cent. when nitrate of soda was added, and by 9.5 per cent. when dried blood was the source of nitrogen. The largest proportion of "firsts" was secured when horse manure was used alone. The results from a larger quantity of chemical manures on plots 11 and 12, though not increasing the yield, showed practically the same relation of large to small, as in group 2; while chemical manures, in connection with horse manure, on 7 and 13, showed relatively more large potatoes. With the exception of plots 7 and 13, the results are, on the whole, in accord with those secured in 1891, though the proportionate increase of large roots is much greater this year than in previous experiments. This, in connection with the character of the season, is of considerable interest.

These results, showing the relative effect of chemical manures and horse manure in proportionately increasing the yield of large potatoes, are very important, not only in indicating the usefulness of manures, but in showing that the opinion now prevalent among growers "that chemical manures or fertilizers increase the yield of small potatoes or roots disproportionately" is erroneous. Where land is suitable for this crop, proper and sufficient nourishment are the important points, not the kind of material that furnishes the food.

FINANCIAL RESULTS.

In this experiment the actual cost of the manures is given, in order that the comparisons may be, as near as possible, in accordance with the facts, though since the cost of the New York horse manure was $2 per ton at consumer's depot, the labor involved in carting and spreading is still ignored. The estimated cost of this work in the present experiment was 50 cents per ton.

The selling prices at time of digging were 70 cents per bushel for the large or "firsts" and 50 cents for the small potatoes or roots. Using these figures and deducting the cost of manures, the results in the column headed "Net value of yield per acre" are secured.

TABLE 2.

Number of Plot.	Cost of Fertilizer per Acre.	Yield of Large Potatoes per Acre.	Yield of Small Potatoes per Acre.	Value of Large Potatoes per Acre.	Value of Small Potatoes per Acre.	Total Value of Yield per Acre.	Net Value of Yield per Acre.	Gain or Loss per Acre.
1	....	bu. 111.9	bu. 70.0	$78.33	$35.00	$113.33	$113.33	....
2	$7.70	177.0	56.3	123.90	28.15	152.05	144.35	31.02
3	12.34	175.6	57.0	122.92	28.50	151.42	139.08	25.75
4	12.34	141.1	51.9	98.77	25.95	124.72	112.38	—0.95
5	40.00	160.7	51.1	112.49	25.55	138.04	98.04	—15.29
6	7.70	164.1	73.0	114.87	36.50	151.37	143.67	30.34
7	26.17	167.8	54.8	117.46	27.40	144.86	118.69	5.36
8	12.34	176.3	58.5	123.41	29.25	152.66	140.32	26.99
9	12.34	148.1	67.4	103.67	33.70	137.37	125.03	11.70
10	40.00	181.1	57.4	126.77	28.70	155.47	115.47	2.14
11	18.51	155.9	60.7	109.13	30.35	139.48	120.97	7.64
12	18.51	143.3	57.4	100.31	28.70	129.01	110.50	—2.83
13	52.34	171.1	50.0	119.77	25.00	144.77	92.43	—20.90
14	....	142.2	64.4	99.54	32.20	131.74	131.74	....

It will be observed from the table that a financial gain followed the use of manures in 8 out of the 12 plots, the gain ranging from $2.14 to $31.02 per acre. It is also noticeable that large quantities of chemical manures alone or chemical manures in connection with horse manure, were the least profitable.

	Cost of Fertilizer.	Net Value of Crop per Acre.	Net Gain.	Net Gain, 1892.	Average for Two Years.
Unfertilized....................	....	$113.13	....	....	....
Chemical manures alone..	$12.34	129.20	$16.07	$29.22	$22.65
Barnyard manure alone...	40.00	106.76	—6.57	4.57	—1.00

A study of the above tabulation shows that the increased yield from chemical manures alone resulted in a net profit per acre of $16.07, while that from the barnyard manure alone, though greater, was worth $6.57 less than the actual cost of the manure at the consumer's depot. *In other words, the experiment this year shows not only that sweet potatoes can be raised by chemical manures alone, but that the increased yield was sufficient to pay a considerable profit.* This result is in accord with those of previous experiments in teaching that relatively small quantities of plant-food, in quickly-available forms, are quite as useful in increasing yield as larger quantities contained in materials possessing valuable mechanical and biological properties in addition to large quantities of the more slowly-available forms of plant-food, and that the profits from the use of these materials increase as their cost decreases. The average net gain for 1892–93 from the use of chemicals is $22.65, while that from the horse manure has been hardly sufficient to pay the cost of the manure. Assuming that the manure has been paid for in this crop, the profits from its use must come from increased yields of subsequent crops.

DOES THE FORM OF NITROGEN USED IN CHEMICAL MANURES INFLUENCE THE GROWTH OF SWEET POTATOES?

Plots 2 and 6 were fertilized with the mineral elements alone or with an incomplete manure containing plant-food equivalent to 52 pounds of available phosphoric acid and 80 pounds of potash per acre. Plots 3 and 8 received in addition 32 pounds of nitrogen in the form of nitrate of soda, and plots 4 and 9 the same quantity of nitrogen in the form of dried blood. Dried blood contains nitrogen in its most available organic form. The comparative value of these forms of nitrogen depends, of course, upon whether either form is useful. The following table will aid in this study:

	Cost of Fertilizer.	Net Value of Crop per Acre.	Net Gain.	Net Gain, 1892.	Average for Two Years.
Unfertilized..............	....	$113.33	....	....	....
Minerals alone...........	$7.70	144.01	$30.68	$25.31	$28.00
" with Nitrate..	12.34	139.70	26.37	23.30	24.84
" " Blood....	12.34	118.71	5.38	35.14	20.26

The net gain from minerals alone is $30.68 per acre. The net gain from minerals with nitrate is $26.37 per acre, or a difference in

favor of minerals alone of $4.31 per acre. The nitrogen costs $4.64 per acre, hence, while there was a slight increase in yield from its use, it was not sufficient to pay the extra cost. This result is in accord with that of 1892.

The use of dried blood in connection with minerals resulted in a lower yield than was secured from the minerals alone, and consequently a much decreased net gain. This effect of dried blood is the reverse of that shown in a similar experiment in 1892 and others in 1891, which showed an increased yield from nitrogen, and that organic forms, as dried blood, were more useful than the nitrate of soda.

ARE COMBINATIONS OF CHEMICAL AND HORSE MANURES MORE PROFITABLE THAN HORSE MANURE ALONE?

This method of manuring is highly regarded by some of the best growers, because it admits of securing the advantages that may be derived from the mechanical and biological properties of the horse manure and from the greater solubility of the chemical manures. Plot 7 received one-half as much and plot 13 the same amounts of manure and chemicals as were used when each was applied singly. The result stands as follows:

	Cost of Fertilizer.	Net Value of Crop per Acre.	Net Gain or Loss.	Net Gain, 1892.	Average Net Gain. or Loss for Two Years.
Unfertilized	....	$113.33	....	....	....
Manure and chemicals, one-half	$26.17	118.69	$5.36	$14.68	$20.02
" " " whole	52.34	92.43	—20.90	16.02	—2.44
Manure alone	40.00	106.76	—6.57	4.57	—1.00

The only net gain was secured from the combination of small quantities of the manure and chemicals; this gain was but $5.36 per acre. Twenty tons of manure per acre, both alone and in combination, with full quantities of minerals, though increasing the yield, resulted in a considerable loss.

In this experiment two of the general conclusions of last year are verified, viz.:

1. That profitable crops can be raised with chemical manures alone, and that the net profits of the crop are greater than from New York horse manure alone.

2. That combinations of chemical and horse manures are more satisfactory than horse manure alone.

In reference to the forms of nitrogen, the results are the reverse of last year, the nitrate of soda being more useful than the dried blood.

Experiments with Fertilizers upon Sweet Potatoes.

BY MR. ALEX. W. PEARSON, VINELAND, N. J.

"The land used in this experiment is in extent 42 yards by 84 yards, and it is subdivided into 14 parallel plots, seven rows in each plot; 51 potato hills in each row. Total, 4,998 hills, which are thirty inches apart each way.

"Fertilizers were applied in the hills on April 22d, and covered by making half hills; the hills were completed May 18th. The sweet potato plants were set on May 22d. The several plots were fertilized as follows:

TABLE 1.

Number of Plot.	FERTILIZER USED. KIND.	Quantity per Acre.	Hills Replanted June 17th.	Hills Dug.	Total Yield per Plot in Pounds.
1	Unfertilized		28	336	175
2	Bone Black Muriate of Potash	320 lbs. 160 "	14	335	435
3	Bone Black Muriate of Potash Nitrate of Soda	320 " 160 " 200 "	63	297	452
4	Bone Black Muriate of Potash Dried Blood	320 " 160 " 280 "	56	319	325
5	Barnyard Manure	1 ton.	30	215	335
6	Bone Black Muriate of Potash	320 lbs. 160 "	20	323	279
7	Barnyard Manure Bone Black Muriate of Potash Nitrate of Soda	½ ton. 160 lbs. 80 " 100 "	16	303	227
8	Bone Black Muriate of Potash Nitrate of Soda	320 " 160 " 200 "	105	280	335
9	Bone Black Muriate of Potash Dried Blood	320 " 160 " 280 "	69	286	282
10	Barnyard Manure	1 ton.	49	308	377
11	Bone Black Muriate of Potash Nitrate of Soda	480 lbs. 240 " 300 "	133	269	228
12	Bone Black Muriate of Potash Dried Blood	480 " 240 " 420 "	149	272	229
13	Barnyard Manure Bone Black Muriate of Potash Nitrate of Soda	1 ton. 320 lbs. 160 " 200 "	180	253	224
14	Unfertilized		26	350	313

"There was not any rain on this place sufficient to wet soft earth, two inches in depth, from May 4th to August 24th; the moisture never got down to the fertilizers covered in the potato hills. It was practically a continuous drought of one hundred and eleven days.

"Many of the potato plants set May 22d died, and these 'missed hills' were replanted June 17th, after a light rain, as given in the table.

"As the plants continued to die under the drought, they were replanted several times after June 17th, but no further account was kept of dead plants. A wetting rain fell August 24th, and after this the potatoes made some growth.

"They were dug October 19th. The potato plants in each plot were counted, and total product of each plot was weighed, as given in Table 1. Total hills planted, 4,998; total hills dug, 4,146; missing hills, 852.

"It will be noticed that the plots 2 and 3 show largest yield. There is a slight depression in the ground of these plots, and drainage from the light showers ran towards them.

"Under the conditions of drought the plots most fully fertilized lost most plants, and hence gave the lowest yield.

"The hills replanted gave little but pig feed; however, the total product of each plot is here registered.

"The best yield of marketable tubers came from the plots of yard manure.

"From previous experiments in the use of chemical manures on sweet potatoes, I am led to believe that under more favorable conditions for growth the results of this experiment might have been different, and rather in favor of the chemical manures."

The above detailed report given by Mr. Pearson is published mainly as a matter of record, since, owing to the drought, no conclusions can be drawn as to the relative value of methods of manuring. The land used in this experiment is much lighter than that of Mr. Brown's, though well adapted for the crop. Sweet potatoes raised in the vicinity of Vineland are always quoted higher in the markets than those from any other portion of the State.

4.

EXPERIMENTS WITH FERTILIZERS ON SALT GRASS.

BY REV. D. H. SHOCK, ISLAND HEIGHTS, N. J.

Number of Plot.	Fertilizer. Kind.	Fertilizer. Quantity per Plot.	Yield per Plot in Pounds.	Pield per Acre in Tons.
1	Unfertilized		938	1.88
2	Nitrate of Soda	40 lbs.	926	1.85
3	Nitrate of Soda	40 "	876	1.75
	Muriate of Potash	40 "		
4	Nitrate of Soda	40 "	965	1.93
	Superphosphate	80 "		
5	Nitrate of Soda	40 "	878	1.76
	Superphosphate	80 "		
	Muriate of Potash	40 "		

There are in this State large areas of low-lying land, suitable only for salt grass. The better kind, and particularly the black grass (*Juncus gerardi*)—the variety grown in the experiment—is largely used as fodder for horses and cattle. The price received per ton, though less than for the best market varieties, makes the crop a fairly profitable one.

The above experiment was planned to determine the effect of an application of the best fertilizing materials. The results this year do not show any beneficial effect from their use. The plots will be kept separate and a further trial made next year.

5.

FIELD EXPERIMENTS WITH FERTILIZERS UPON PEACH TREES.

BY STEPHEN C. DAYTON, BASKING RIDGE, SOMERSET COUNTY.

TABLE 1.

Number of Plot.	Fertilizers. Kind.	Fertilizers. Quantity per Acre.	Number of Bearing Trees per Plot.	Baskets of Peaches per Plot.	Average Number of Baskets per Tree.	Baskets of Peaches per Acre of 130 Trees.
1	Unfertilized..........	....	12	4.5	0.4	52
2	Nitrate of Soda.......	150 lbs.	9	5.0	0.6	78
3	Superphosphate......	350 "	13	10.5	0.8	104
4	Muriate of Potash...	150 "	12	19.3	1.6	208
5	Nitrate of Soda....... Superphosphate......	150 " 350 "	12	20.3	1.7	221
6	Unfertilized..........	....	13	18.5	1.4	182
7	Nitrate of Soda...... Muriate of Potash...	150 " 150 "	12	26.0	2.2	286
8	Superphosphate...... Muriate of Potash...	350 " 150 "	12	31.8	2.6	338
9	Nitrate of Soda...... Superphosphate...... Muriate of Potash...	150 " 350 " 150 "	11	30.8	2.8	364
10	Plaster	400 "	11	19.8	1.8	234
11	Barnyard Manure...	20 2-horse loads.	10	34.3	3.4	422
12	Barnyard Manure... Lime....................	10 loads. 50 bushels.	12	14.8	1.2	146

This experimental orchard was set in April, 1884, and reports of the management of the orchard and the crops harvested have been made regularly in previous annual reports of the Station.

On October 9th, Mr. Dayton reported as follows:

"The high winds this fall destroyed much fruit, and greatly damaged the trees—uprooted, broke down and entirely destroyed two trees in plot 1, four trees in plot 2, three in plot 3, two in plot 4, two in plot 5, two in plot 9 and one each in plots 9 and 12, beside greatly injuring many others.

"The fertilizers have been applied this year as usual, and the plots have received the same cultivation. The plots on which nitrate of soda and potash have been used, either alone or together, are almost as bare of vegetation as the middle of the road, but in the plot on which phosphate, barnyard manure and lime were applied weeds and grass persist in growing, and yet from these experiments potash seems to be the ruling fertilizing element for peaches, producing more fruit and of better quality than any of the others.

"Lime seems good for grass, but very poor for peaches.

"Of course, it is impossible to say how much fruit was destroyed by the wind, or whether there was more destroyed on one plot than another, but as the wind struck heaviest on the west side, it is likely that the loss was greatest on that side—plots 1, 2 and 3."

As stated in previous reports, "it has become evident that the trees are still too close to prevent them from feeding from adjoining plots. This is especially noticeable on plot 6, where, without any manure, there has been an unusual development for the past three or four years."

Table 1 shows the amount and kind of fertilizer used per acre on the different plots since the experiment began, and the yield secured this year.

The yields secured this year on many of the plots are large, notwithstanding the adverse conditions reported by Mr. Dayton, which were true for the whole State. The trees are, of course, large, yet this crop is the sixth harvested, or double the number secured under the average conditions of culture in the State, as represented by plot 1, and from which three crops have been harvested. The yield from the barnyard manure plot is the largest, as has been the case, with one or two exceptions, since the first crop, in 1887. The next largest yield is on plot 9, receiving the complete manure. Of the single fertilizing ingredients, potash still exerts the most favorable influence. Nitrate of soda alone seems to have exerted an unfavorable influence from the beginning.

Table 2 shows the yields of the different plots from 1887 to 1893, inclusive. The yield on plot 6 is disregarded in all comparisons, for the reasons already given. Plot 1 is assumed to represent the average yield of the unmanured land.

TABLE 2.

Number of Plot.	TOTAL YIELD PER ACRE, IN BASKETS.							
	1887.	1888.	1889.	1891.	1892.	1893.	Total Yield for Six Years.	Net Increase for Six Years.
1	106.6	158.6	10.9	249.6	26.0	52.0	603.7	....
2	81.6	149.5	32.0	247.0	26.0	78.0	614.1	10.4
3	162.5	224.9	70.5	364.0	117.0	104.0	1042.9	439.2
4	123.5	230.1	117.8	496.6	143.0	208.0	1319.0	715.3
5	140.7	344.5	98.8	468.0	182.0	221.0	1455.0	851.3
6	120.0	252.2	108.8	392.5	104.0	182.0	1159.5	....
7	113.8	295.0	166.7	455.0	52.0	286.0	1368.5	764.8
8	173.6	322.4	150.0	431.6	169.0	338.0	1584.6	980.9
9	152.2	418.6	152.5	591.5	156.0	364.0	1834.8	1231.1
10	131.3	285.7	105.7	449.8	91.0	234.0	1297.5	693.8
11	147.6	433.9	162.5	612.4	169.0	422.0	1947.4	1343.7
12	62.4	267.8	144.4	387.4	156.0	146.0	1164.0	560.3

Of the single elements, nitrate of soda has not increased the yield; superphosphate and potash on plots 3 and 4 have both been effective, though still decidedly in favor of the potash, the net increase in yield on plot 4 being 276 baskets, or 62.8 per cent. greater than on plot 3. The increased yields from combinations of two elements on plots 5, 7 and 8 are large, though the proportionate increase this year is much greater on plot 8 than upon plot 5. The best yield from the chemical manures is from the complete fertilizer on plot 9. The largest yield

is from barnyard manure on plot 11, being 112 baskets greater than on plot 9. Crawford's Late, the variety grown, is regarded as a shy bearer, still on plots 9 and 11, which received a complete plant-food, the average yield for the seven years, 1887 to 1893, inclusive, is 276 baskets per acre, or practically two baskets per tree. If 1890 is excluded, a year in which all varieties failed, the average yield for these plots is 315 baskets per year, as against 100 for the unmanured land represented by plot 1.

Averaging the best three years—1887, 1888 and 1891—we find that the unmanured land reached but 171 baskets per acre.

TABLE 3.

Number of Plot.	Cost of Fertilizer per Acre.	Value of Crop per Acre. 1887.	1888.	1889.	1891.	1892.	1893.	Total Value.	Net Value.	Net Gain or Loss.
1	....	$53.30	$79.30	$5.45	$124.80	$13.00	$26.00	$301.85	$301.80	....
2	$40.50	40.80	75.00	16.00	123.50	13.00	39.00	307.30	266.80	—$35.00
3	36.70	81.25	112.45	35.25	182.00	58.50	52.00	521.45	484.70	182.90
4	30.00	61.75	115.05	58.90	248.30	71.50	144.00	659.50	629.50	327.70
5	77.20	70.35	172.25	49.40	234.00	91.00	110.50	727.50	650.30	348.50
6	....	60.00	126.10	54.40	196.75	52.00	91.00	580.25	580.25	....
7	70.50	56.90	147.50	83.35	227.50	26.00	143.00	684.25	613.75	311.95
8	66.70	86.80	161.25	75.00	215.80	84.50	169.00	792.35	725.65	423.85
9	107.20	76.10	209.30	76.25	295.75	78.00	182.00	917.40	810.20	508.40
10	15.00	65.65	142.85	53.85	224.90	45.50	117.00	649.75	634.75	332.95
11	300.00	73.80	216.95	81 25	306.20	84.50	211.00	973.70	673.70	371.90
12	200.00	31.20	133.90	72.20	193.70	78.00	73.00	582.00	382.00	80.20

Table 3 shows the value of the crops harvested and also the net gain or loss per acre when the total cost of the fertilizers and manures is deducted. In estimating values, 50 cents per basket has been used as heretofore. This year, however, prices ruled much lower than in any previous year. There is a decided gain in all cases except from the use of nitrate of soda alone on plot 2, which shows a loss of $35 to date. Of the single elements, potash has proved the most valuable.

Superphosphate was also profitable, and its use, together with potash, on plot 8 shows the highest net gain from an incomplete fertilizer.

Nitrate of soda seems also to have been effective when used in connection with superphosphates. Barnyard manure and lime on plot 14 proved the least profitable of the materials used, except the nitrate of soda on plot 2. The cost of the manure on plot 11 renders it a much less profitable manure than the other materials furnishing plant-food, though no ill effects have been observed from the large quantities annually applied.

Field Experiments with Fertilizers Upon Peach Trees.

BY S. S. VOORHEES, MINE BROOK, SOMERSET COUNTY.

The object of this experiment is to test—

1. The effect upon the health and productiveness of peach trees of what may be considered a sufficient excess of the plant-food elements, nitrogen, phosphoric acid and potash, the first application to be made at the time of setting the trees, and thereafter as often as deemed necessary.

2. The effect of nitrogen and phosphoric acid from different sources. On plot 1 the nitrogen used is all in the form of nitrate of soda, and the phosphoric acid is derived entirely from bone-black superphosphate; on plot 2 the nitrogen and phosphoric acid are derived entirely from ground bone and ground fish. The potash is from muriate of potash in both cases.

The experiment contains three plots, one-fourth of an acre in area, each plot containing one row of 47 trees.

The soil is a gravelly loam, high and well drained, and in a good state of cultivation. The field was seeded to wheat in 1888, and mowed and lightly pastured in 1889. The trees were set and corn planted on May 1st, 1890, and fertilizers applied broadcast on May 7th, just before a heavy rain.

The applications and cost of fertilizers and the crop harvested are given in the following tabulation:

Number of Plot.	FERTILIZERS.								Total Value of Crop per Acre.
	KIND.	QUANTITY APPLIED PER ACRE.					Cost per Acre for the three Years.		
		May 1, 1890.	April 1, 1891.	April 21, 1892.	Nov. 29, 1892.	May 1, 1893.			
1	Nitrate of Soda......	160 lbs.	160 lbs.	160 lbs.	....	160 lbs.	$15.36	$32.88	$55.76
	Bone Black...........	240 "	....	240 "	....	240 "	7.92		
	Muriate of Potash..	160 "	....	160 "	160 lbs.	....	9.60		
2	Ground Bone........	600 "	....	400 "	400 "	....	21.00	39.60	75.27
	Ground Fish.........	....	600 lbs.	....	....	....	9.00		
	Muriate of Potash..	160 "	....	160 lbs.	160 lbs.	....	9.60		
3	Unfertilized..........	....	....	....	....	....	....		44.67

Corn was grown in the orchard in 1890 and 1891; in 1892 the orchard was cut, harrowed twice and plowed, and seeded to scarlet clover on August 20th. The effect of fertilizers, while very apparent on the crops of corn and clover, is not particularly noticeable on the trees, the main difference being a deeper color and stronger growth of foliage on the fertilized plots.

A number of the trees bore this year, though unfortunately owing to a misunderstanding on the part of Mr. Voorhees, no accurate record was kept of the yield of fruit on the different plots.

6.

EXPERIMENTS WITH FERTILIZERS UPON STRAWBERRIES.

The plants were set in a peach orchard in the spring of 1891, and fertilized at time of setting with 1,650 pounds per acre of a mixture consisting of 1,000 pounds of kainit, 500 pounds of ground bone and 150 pounds of nitrate of soda. The soil was a sandy loam with clayey subsoil, well drained and of medium quality. The whole area set was two acres, divided by rows of peach trees into plots of one-fifth of an acre, containing four rows of plants each, and separated by a space of eight feet. The Sharpless variety was selected for the experiment.

During the season of 1891, the plants were carefully cultivated and kept free from weeds, and made an unusually fine growth. In the spring of 1892, with one exception, the plots received a dressing of

200 pounds of nitrate of soda per acre, as indicated in the report for 1892. This spring the plots, with one exception, were again fertilized with nitrate of soda, at the rate of 160 pounds per acre.

The effect of the spring application of nitrate was apparent almost immediately; the plants assumed a richer color and showed a stronger and more vigorous growth than those upon which no application was made. The plants blossomed well and the berries set full in all cases. At the time of picking, the fruit on the nitrated plots was larger though no earlier than upon the plots upon which no application had been made, as in 1892. The total yield was materially reduced on all the plots—in fact the crop was practically ruined this year; the very dry weather late in May and early June, was followed at time of ripening with a wet, muggy spell, which softened and rotted the fruit to such an extent as to render it practically worthless. The selling price of the berries averaged 12 cents per quart.

The following tabulation shows the cost of manures, and the yield and value of the crop for 1892, and the net value of the crops for 1892–93:

Number of Plot.	FERTILIZER PER ACRE.	Cost per Acre.	Yield per Plot.	Yield per Acre.	Value per Acre.	Net Value per Acre, 1892 and 1893.	Net Gain for two Years.
			qts.	qts.			
1	150 lbs. Nitrate of Soda. 500 " Ground Bone.... 1,000 " Kainit..............	$14.87	142	710	$88.20	$211.33	....
2	Same as Plot 1, with 360 lbs. Nitrate of Soda added in the spring........	22.97	172	860	103.20	246.73	$35.40

The gain in yield, due to the spring application of nitrate, was 150 quarts per acre, or 21 per cent. The net gain for the two years—$35.40 per acre—or, in other words, an expenditure of $8.10 for nitrate of soda, has resulted, even in unfavorable seasons, in a net return equivalent to $4.37 for every $1 invested. This rate of increase, applied to a full crop, will show the enormous value of an early application of quickly-available nitrogen.

This method of fertilizing is now in quite general use in the berry districts and it is giving good satisfaction, and is strongly recommended. The following suggestions from the "Journal of Horticulture," London, in reference to methods of application of nitrate of soda and its usefulness for small fruits in general, coincides with the experience of our own growers who have used it:

"The effect of nitrate of soda on strawberries, especially in light soils, is magical, doubling and trebling the yield. If any one doubts this, let them try a large dressing of nitrate of soda on an old strawberry bed, first of all freeing it from weeds and grass. Sow it (powdered) broadcast early in the spring and give another dressing a few weeks later. The effect will be also to kill slugs and other predatory pests that fatten on strawberries, which is an important consideration. The best time to apply nitrate of soda to strawberries is when they are commencing growth, and if more stimulus is needed supply another dressing after the fruit is well set. Scatter it between the rows and plants, not on them. It is desirable to use superphosphate as well as nitrate of soda on strawberry plantations, for the one tends to the production of fruit and the other to swell it to large and handsome proportions. Nitrate of soda is equally as good for raspberries as for strawberries. The larvæ of various pests lurking and feeding on the roots of these plants, disliking nitric acid, become less troublesome in the adult stage, because there are fewer that live to it. The nitrate of soda helps the raspberries to produce abundant crops and sustains them in droughty seasons. On currants and gooseberries, applied each side of the rows early in the spring, it is productive of large, fine fruit."

MISCELLANEOUS EXPERIMENTS.

I.

EXPERIMENT WITH FERTILIZERS ON ASPARAGUS.

BY CHARLES TINDALL, MIDDLETOWN, N. J.

The object of this experiment is to determine whether asparagus can be profitably grown with commercial manures alone. A field of three acres is included in the experiment; it is a sandy loam, and of good natural drainage, and well adapted for the crop. The variety used is Barr's "Mammoth." On April 11th, 1893, one-year-old crowns were set in rows two and one-half feet apart, and, after lightly covering with earth, 400 pounds per acre of a mixture composed of 150 pounds of nitrate of soda, 400 pounds of ground bone, 250 pounds of bone-black superphosphate, and 200 pounds of potash, was distributed evenly over the row, covering a space about 12 inches wide, and on May 8th a second application of 600 pounds per acre of the same mixture, making a total of 41 pounds of nitrogen, 120 pounds of phosphoric acid, and 100 pounds of potash per acre.

The plant-food applied from year to year will be of the kind and amount deemed most useful, and the cultivation and management such as to conform to the best methods of practice. An accurate record will be kept of the expenses attending the crop, as well as the yield and value of the product.

No unfertilized plot is included in the experiment, since all growers agree that it pays to manure in some form.

II.

THE IMPROVEMENT OF LIGHT LANDS BY GREEN-MANURING.

That large areas of light sandy land in this State are susceptible of great improvement, by means of green-manuring, is abundantly evident where the system has been intelligently practiced. Land in any part of New Jersey has the great advantage of nearby markets, and the poorer lands have the further advantage of being naturally

well adapted for market-garden, fruit and berry crops, usually the most profitable in the Eastern States. The location and natural adaptation of these lands being favorable, a study of soil requirements becomes doubly important, and it has reference both to physical character and chemical composition.

The decaying organic matter in green manures improves by making the land more retentive of moisture and plant-food, and by depositing in the surface soil nitrogen—originally existing in the air—and mineral constituents—previously existing in the lower layers of the soil. Green-manuring does not add to the total of mineral constituents in a soil; it simply changes their position; they must be added if any increase in them is desired. The legumes—peas, beans, clover, etc.—are best adapted for green manures, because of their great leaf development and because of their ability to flourish with limited supplies in the soil of the expensive element nitrogen.

An experiment to test the importance of green-manuring, mainly with leguminous plants, as a factor in the improvement of light lands, was begun this year upon the farm of Mr. Hal Allaire, of Allaire, Monmouth county.

The land used was one acre in area; it is a light sandy loam, with a clayey subsoil and good natural drainage. The first crop grown on this land, after clearing it, was scarlet clover, sown in August, 1892; the clover made but a poor growth, although there was a fair catch. This crop was turned under May 20th. The land was then thoroughly prepared, dressed with one-half ton of kainit and one-half ton of odorless phosphate, and seeded broadcast with one bushel of cow peas on May 27th. The peas came up well and made a rapid and continuous growth, notwithstanding the dry season. On August 12th they were about 18 inches high, and beginning to vine.

Since the land is somewhat exposed and blowy it was the intention to let the crop remain upon the land until spring, hence scarlet clover was sown among the peas on July 29th. Owing, however, to the dry weather the seed of the clover perished, and the peas were plowed down September 9th, when the crop had reached its full growth, and seeded with rye September 13th. Before plowing, one square rod—representing as nearly as possible the average crop—was cut and weighed, and a sample, both of the vines and roots, taken for analyses to determine the yield of organic matter and fertilizer constituents gathered by the crop.

The weight of crop on a square rod was 90 pounds, or an equivalent of 14,400 pounds per acre. The proportion by weight of roots to top was also determined, which showed the weight of roots to be 1,080 pounds per acre, from the surface of the soil to a depth of 8 inches. The amount of organic matter contained in vines and roots, as well as the total plant-food gathered, is given in the following table:

	Organic Dry Matter, Lbs.	Nitrogen, Lbs.	Phosphoric Acid, Lbs.	Potash, Lbs.
Vines	2,278.1	70.6	17.3	50.4
Roots	295.2	4.2	1.5	4.4
Total	2,574.3	74.8	18.8	54.8

The complete chemical analyses of these samples are contained in the table on page 161.

It will be observed that the roots contained but a small proportion of the total plant-food gathered by the plant. The amount stored in the vines is, however, considerable, particularly of nitrogen—the expensive element gathered from the air—and is equivalent to 437.5 pounds of nitrate of soda, worth about $11.

The total organic matter, so useful in improving physical character, is equivalent to that contained in 10 tons of yard manure.

The plan outlined for this experiment contemplates turning under the rye in the spring and planting field corn, sowing scarlet clover in the corn and following the next year with potatoes, and thus gradually working toward the growth of those crops that are profitable, while, at the same time, testing the usefulness of various green manure crops as sources of nitrogen and organic matter.

The cow pea as a green manure crop has not been extensively used in the State, and its merits are not well known. The following report by Mr. Howe, in reference to the seeding and management of the crop for this purpose, as well as the benefits that have been derived, is, therefore, of considerable interest in this connection:

Experiments with Cow Peas on Brookdale Farm, Red Bank, N. J.

BY H. V. HOWE, MANAGER.

"My experience with cow peas as green manure began in the spring of 1888. In that and the following years we sowed in all 740 acres on soils varying from a heavy clay loam to a very light, poor soil.

TIME OF SEEDING AND AMOUNT OF SEED PER ACRE.

"We sowed each year, the last week of May and first week of June, one and one-half bushels on light soil to two bushels on clay loam. On the sand, the vines grew from eight to twenty inches in length, and on the clay, sometimes five to six feet, and were very difficult to plow under, as the vines have a habit of twisting around each other like hop vines, and are not easily cut with any attachment to the plow. After trying various methods, I found that the wheel coulter attached to the plow and kept sharp would cut the vines if green. When the vines commence to ripen they get tough and hard.

"After growing cow peas, when next plowed we could always observe that the soil was darker.

TIME TO PLOW UNDER.

"We usually began plowing under about the 15th of August. On the clay soils we generally followed with a crop of rye and seeded the land to grass with timothy and clover without any other manure or fertilizer. The crops of rye were always heavy, also the following crops of grass.

"I will mention two instances as examples of the beneficial effect of that method of manuring.

BENEFITS OF GREEN-MANURING WITH COW PEAS.

"The first is a field of 15 acres of very poor sand; the ridges especially were very light and poor. It had not had any crop on for three or four years, and on the 1st of June the only growth was a few wild onions, with here and there a briar. It was formerly a peach orchard, from which we removed the stumps, which were small, showing that the trees did not make a good growth. We sowed cow peas one and one-half bushels per acre, which grew to from eight to twelve inches; we plowed down in August and sowed rye, which made only a small growth, especially on the ridges. That winter we spread fifty bushels of slaked lime per acre. Next May we plowed in the rye; we sowed cow peas again, and they made a better growth, from twelve to sixteen inches, and followed in the autumn with rye, which

also made a better growth. We applied no manure in that time, except on some of the ridges, in the first winter, where the sand began to blow away; we spread there, lightly, fresh horse manure, chiefly litter, to protect it. The land was then sown to grass, timothy and clover, which made, on the best parts, a fair growth. It remained so for two years. Last spring we put in oats with 400 pounds of Mapes' 'Complete Manure for Light Soils.' We had a moderate crop of oats, but cut them before they were ripe to feed to horses in the sheaf. It then gave a good growth of weeds, chiefly rag weeds, which were plowed under in September and sown to rye, of which there is a nice growth at present. I might mention that on similar land, separated by a road from the above, the only crop grown in the past five years was, in one instance, fodder corn, of which there was a small growth, and a small growth of weeds each year.

"The other instance was a field of 18 acres sandy loam, which showed by the stubble, when I took charge, that on a part of it the year previous there had been a small crop of oats; part of it had been to corn, and about 3 acres to timothy, which looked very poor. It had been let to tenants for over 100 years, and I know nothing about its culture or manuring, but it was then in an impoverished condition. When we first plowed it, in May, there was little growth of weeds of any kind. The cow peas were drilled in at the rate of $1\frac{3}{4}$ bushels per acre. It had made a growth of about 12 to 16 inches when plowed in, the first week of September. It was then seeded with rye, at the rate of $1\frac{1}{2}$ bushels per acre, which made a moderate growth. Freshly-slaked lime was spread in the winter, at the rate of 50 bushels to the acre. The rye was plowed the following spring, and cow peas again put in, which made a much better growth than the previous year. This was followed by rye that made a good growth; so much so that farmers who passed by on the road adjoining the field remarked the difference compared with previous years, and when plowed in, the last week of April, several said 'What a pity it was to plow in such a crop.' We then planted it to corn, without any other manure, in hills 4 feet by 4 feet, three grains in a hill, and had, what I estimated, by measuring in the crib, to be 50 bushels shelled corn per acre. We sowed rye among the corn in August, plowed it the following spring and put in cow peas, which made a good growth and was plowed in in September, and rye drilled in, which gave us a heavy crop this year."

III.

A STUDY OF A ROTATION FOR DAIRY FARMS.

The objects of this study are: (1) To determine whether a definite plan of "intensive" cropping—suitable for the dairy, and which will furnish a continuous supply of green food—may be successfully carried out; and (2) To secure exact information as to the proportionate yield and value of the various crops grown.

The rotation plan outlined is as follows:

First year—Field corn, seeded to scarlet clover in July or August.

Second year—Scarlet clover, followed by fodder corn and the land seeded to rye after the corn.

Third year—Rye fodder, followed by oats and peas, seeded to red clover and timothy.

Fourth year—Hay.

This experimental area includes four acres upon the College farm; the land is clay loam, well drained, reasonably level and uniform in character, and in a good state of fertility. The crops and manures for the four preceding years were: 1889, timothy and clover, no manure; 1890, hay, top-dressed with 150 pounds of nitrate of soda per acre; 1891, hay, top-dressed with ten tons of yard manure per acre; 1892, pasture, no manure.

The land was thoroughly prepared and planted with corn May 14th, and after final cultivation was seeded to scarlet clover July 26th. The very dry weather in July materially retarded the growth of corn, and also prevented a good even catch of clover. In August, severe wind storms further damaged the corn, the yield being much less than a half crop. The clover at the beginning of winter looked remarkably well, as to size and vigor, though unevenly distributed, only covering about two-thirds of the ground.

The corn and stalks were weighed at time of husking, and samples taken for analyses, to determine the amount of food constituents contained in and the fertilizer constituents removed by the crop. The yield was as follows:

	Total Yield, Lbs.	Yield per Acre, Lbs.
Ears of Corn	9,960	2,490
Stalks	10,600	2,650

The ears of corn consisted of 76.08 per cent. grain and 23.92 per cent. cob. The food analyses of these products are reported in the table on page 161, and these applied to the weights show the following amounts of food constituents obtained per acre:

	POUNDS OF				
	Fat.	Fiber.	Protein.	Ash.	Carbohydrates.
Corn	75.59	31.26	169.36	26.90	1,110.69
Cobs	1.49	104.10	10.37	6.26	189.64
Stalks	23.59	503.18	161.12	138.60	827.33
Total	100.67	638.54	341.85	174.76	2,127.66

The fertilizer analyses show that the following amounts of constituents were removed per acre:

	POUNDS OF		
	Nitrogen.	Phosphoric Acid.	Potash.
Corn	27.09	11.56	6.44
Cobs	1.67	4.77	2.68
Stalks	25.71	10.07	23.06
Total	54.47	26.40	32.18

CROP TESTS.

I.

SCARLET CLOVER.

In the report for 1892 twenty-one farmers, representing ten counties of the State, reported their experience with this crop. The evidence furnished by these farmers was uniformly favorable as to its hardiness and adaptability to conditions of the State, and its usefulness for a variety of purposes.

The experiments begun by the Station, as noted in that report, were carried out, and a detailed study made of the composition of the crop at different stages of growth. The full results of the study are now being prepared for publication in bulletin form, hence only a general report is recorded here.

The experiment plots were one acre in area, and located as follows:

Plot No. 1. J. M. White, New Brunswick, Middlesex county.
" No. 2. College Farm, " " " "
" No. 3. Hal Allaire, Allaire, Monmouth county.

Plot No. 1 was seeded August 13th, in a seven-year-old peach orchard; the land is a light sandy loam with a clay subsoil, though well supplied with the mineral elements. Plot No. 2 was seeded after a crop of potatoes, on September 1st; the land is a gravelly clay loam, with a tight clay subsoil, and is in a high state of fertility. Plot No. 3 was sown September 15th; the soil has not been cropped and is a very light sand underlaid with clay.

Sixteen pounds of seed were sown per acre, and although the fall was very dry, the growth on plots 1 and 2 was strong and vigorous, measuring six inches in height at the beginning of winter, and is apparently too thick for best results. On plot 3, sowed later, the growth is not so heavy, though well established.

EXPERIMENT NO. 1.

In this experiment apparently all of the plants survived the winter and spring, and made a rapid early growth. On May 24th the plants were in full bloom, were about two feet high, and the crop was quite

uniform in size and thickness. On this date, one square rod, representing a full stand, was cut and weighed; the yield was 140 pounds equivalent to 22,540 per acre, or 11¼ tons. The analysis of the sample is given in the table of analyses of fodders and feeds under No. 831.

The crop was plowed under as a green manure about June 1st, and, although the growth of the clover seemed to affect the peach trees somewhat unfavorably, they revived very soon after the plowing under of the clover, and in a short time were quite as vigorous in appearance as the remainder of the orchard, which had received instead a dressing of 160 pounds of nitrate of soda per acre.

There were four rows of trees in the plot, which extended entirely across the orchard, and included nearly all the varieties grown. The crop of peaches harvested was as satisfactory, both in yield and quality, as that gathered on the remainder of the orchard.

EXPERIMENT NO. 2.

A full stand was not secured on the whole of this plot, due, partially, to the dry weather of the fall, and also to slight winter-killing on exposed portions. On about one-half of the area the clover was very thick at the opening of spring. The growth, though slower early than on the light land in experiment No. 1, matured about as early and made a taller and heavier crop. It averaged about 34 inches in height. One square rod, representing full stand, was cut and weighed on May 24th. The weight was 250 pounds. And another on May 31st which weighed 210 pounds, or an average of 230 pounds, equivalent to 36,800 pounds per acre, or 18.4 tons.

The crop was fed green to dairy cows, and its high quality, as shown by its analysis, was fully verified in the feeding. The animals were especially fond of it and responded by increased yields. A detailed study of the composition of the crops on experiments 1 and 2 is now in progress in the laboratory, the results of which will be published in bulletin form in the early summer.

EXPERIMENT NO. 3.

The plants on this plot, though surviving the winter, made but a slight growth in the spring. The average height did not exceed six inches. It is quite evident that scarlet clover, in common with other

plants, cannot make a strong growth without an abundance of available mineral food. The crop was plowed under May 27th and the plot seeded to cow peas.

EXPERIMENTS BEGUN IN 1893.

Four experiments with scarlet clover are in progress this year, as follows:

No. 1. College Farm, New Brunswick, Middlesex county.
" 2. John Voorhees, South Branch, Somerset county.
" 3. Samuel Read, Mount Herman, Warren county.
" 4. J. A. McBride, Deckertown, Sussex county.

The purpose of these experiments is:

1. To test its hardiness for the central and northern portions of the State.
2. To test different methods of seeding.
3. To further study its usefulness as pasture, as green fodder and as hay.

II.

SUGAR BEETS.

The following letter was received by the Station September 29th, 1893:

"We have planted for experimental purposes four kinds of sugar beets, namely:

"Kleinwanzleben, Silesian, Imperial, Red Top.

"The seed was received from D. Landreth & Son, of Philadelphia. Would your Experiment Station chemist make an analysis? If so, I will send to you samples of every kind and size. We are located in Cape May county, about fourteen miles north of Rio Grande, where the New Jersey Department of Agriculture has experimented with sorghum.

"Very truly yours,

"H. L. SABSOVICH, *Supt.*"

In reply to this communication, it was stated that if full data concerning growth of the beets were furnished, the chemical analyses would be made. In response to this letter the following description of soil and method of growing the beets was received:

"We are located fifty-six miles south of Philadelphia and twenty-two north of Cape May City, in Cape May county. The general character of the soil is a sandy loam, with a good fertilizer, retaining bottom of a heavier loam mixed with gravel. We have cleared over 1,000 acres; about 100 acres for farming purposes. Our land is under cultivation the second season. The first season of 1892 gave us a very small crop of everything, as the soil was not yet mechanically well prepared or worked out; but this second year, on 24 to 25 farms (the whole number of farms in our colony is 67 under cultivation, * * * for the present 54), we have a good crop of early truck. We have given out sugar beets to different parties, but under our control only two places remained, my own farm and the company's farm. I have planted nine square rods, and on the company's farm forty-eight square rods. As stated before, the land was twice plowed, in the spring of 1892 and 1893. The forty-eight square rods were stumped—that is, the stumps have been taken out; the nine rods only worked over by spade. I dug shallow ditches about six inches deep, filled in with the dug-out dirt, put on fertilizer at the rate of 800 pounds to the acre, and covered the fertilizer with six inches of dirt, so that ridges have been formed about six inches above the level; then furrows of about two inches deep were made, and the seeds soaked for forty-eight hours in diluted cow urine, in sacks, and then they were drilled in by hand May 5th, when the average temperature was 54° F. The mean temperature for the month of May was 58.5° F.

"The fertilizer contained about 5 per cent. nitrogen, 8 per cent. phosphoric acid and 8 per cent. potash. On the 18th of May the beets came up; first cultivation by hand, the last two by one-horse plow. The ridges have been made one foot wide, and three and one-half feet between, so a cultivator or plow could be run. The beets have been thinned out to eight inches between the beets in the row. I cannot give estimate of the yield; there are beets from one to two and one-half pounds weight."

The following table gives the yield of beets on the different plots and their chemical analyses:

VARIETY OF BEET.	Number of Farm.	Area Planted.	Actual Yield of Cleaned Beets.	Estimated Yield per Acre of Cleaned and Topped Beets.	Per cent. of Sugar in Expressed Juice.	Per cent. of Solids in Expressed Juice (Brix).	Co-efficient of Purity.	Per cent. of Sugar in Cleaned and Topped Beets (calculated).	Yield of Sugar per Acre.
		sq.rods.	lbs.	tons.					tons.
Kleinwanzleben..........	59	2.50	350	9.74	12.90	17.3	74.6	12.25	1.19
Red Top........................	"	2.50	295	8.21	11.13	15.1	73.7	10.57	0.87
Imperial........................	"	3.25	358	7.67	10.18	14.3	71.2	9.67	0.74
Silesian.........................	"	3.25	332	7.11	14.86	19.1	77.8	14.12	1.00
Kleinwanzleben..........	60	6.50	500	5.35	16.05	19.9	80.7	15.25	0.82
Red Top........................	"	15.00	1,312	6.09	12.71	16.7	76.1	12.07	0.74
Imperial........................	"	15.00	1,700	7.89	12.16	16.1	75.5	11.55	0.91
Silesian.........................	"	15.00	1,160	5.38	13.61	17.1	79.6	12.93	0.70

FODDERS AND FEEDS.

I.

ANALYSES.

The analyses of fodders and feeds made this year are tabulated on the following pages. The larger number of these analyses have been made necessary by the feeding and crop experiments conducted by the Station during the past year, and have been or will be properly discussed elsewhere.

The analyses of Nos. 853, 854, 855 and 857, represent the products at the time of husking the corn, hence they show a much higher content of moisture than the average.

The samples of sugar beets are shown by analyses to be relatively rich in dry matter; their palatability, in connection with a high rate of digestibility, makes them very useful as fodders, though the cost of raising a crop, and the relatively low yield that may be secured under average conditions, make them a rather expensive source of food.

Sample No. 842, though called "Chicago Gluten Meal," differs very materially from sample No. 856; the latter corresponds in composition to what we have previously examined and reported under that name.

There is no doubt but that the former is a refuse product from the manufacture of starch from corn, though it has apparently received an undue admixture of corn bran, which it resembles in composition. The price per ton, $19, though perhaps not too high, is much higher proportionately than for sample No. 856, $25 per ton, especially if the object of the purchase is to secure a product rich in protein.

These corn products are excellent feeds, particularly for the dairy, but the names now attached to them by the manufacturers do not, in all cases, indicate their true character, thus causing confusion among consumers and hesitation about buying. The Station has, therefore, begun an investigation of the various products resulting from the manufacture of starch and glucose from corn, viz., glucose meal, germ meal, cream gluten, gluten feed, corn bran, etc., in order that they may be properly classified on the basis of their chemical composition.

No. 812—Rice Polish—is a product new to our State; it is rich in fat and protein, and has given excellent satisfaction where used in the dairy. At the selling price of $18 per ton, it is much cheaper than wheat bran at present prices; it also possesses quite as high a fertility value as the bran.

Paine's Stock Feed, No. 815, is also an excellent product; it resembles rice bran in composition, which is less valuable than the polish, though its selling price, $23 per ton, is much higher, and its fertility value considerably less.

Station Number.	SAMPLE OF	SOURCE.	SAMPLED BY
827	Scarlet Clover, Green......	College Farm, May 12, '93.	Station.
828	" " "	Farm of J. M. White, May 12, '93.	"
831	" " "	" " " May 24, '93.	"
834	" " "	College Farm, May 24, '93.	"
837	" " "	" " May 31, '93.	"
840	Cow Pea Vine..................	Green Manure Exp., Allaire, N. J.	"
857	Corn Fodder.....................	College Farm, Feeding Exp.	"
853	Corn Stalks......................	" " Rotation Exp.	"
854	Shelled Corn....................	" " " "	"
855	Corn Cob	" " " "	"
844	Sugar Beets (Kleinwanzleben)	Jewish Colony, Woodbine.	L. Sabsovich, Supt.
845	Sugar Beets (Red Top)....	" " "	" "
846	" " (Imperial)....	" " "	" "
847	" " (Silesian)......	" " "	" "
848	Corn Grain......................	College Farm, Feeding Exp.	Station.
849	Corn Meal........................	" " " "	"
867	" "	" " " "	"
842	Chicago Gluten Meal......	Narr & Comley, Philadelphia, Pa.	C. Collins, Moorestown.
856	" " "	Chicago Sugar Ref. Co., Chicago, Ill.	E. Burrough, Merchantville.
843	Buffalo Gluten Feed.......	American Glucose Co., Buffalo, N. Y.	T. Borton, Mullica Hill.
852	Dried Brewers' Grains.....	College Farm, Feeding Exp.	Station.
863	" " "	" " " "	"
865	Wet Brewers' Grains.......	" " " "	"
851	Wheat Bran.....................	" " " "	"
866	" "	" " " "	"
811	Cotton-Seed Meal............	American Cotton Oil Co., N. Y. City.	D. D. Denise, Freehold.
858	" "	College Farm, Feeding Exp.	Station.
813	Linseed Meal, O. P.........	Howell Bros., Morrisville, Pa.	G.W.Hockenbury, Locktown.
814	" " O. P.........	D. Worman, Frenchtown, N. J.	" "
850	" " N. P.........	College Farm, Feeding Exp.	Station.
812	Rice Polish......................	C. H. Reeves, New York City.	P. Lindsley, Raritan.
815	Pure Ground Stock Feed..	Paine Fertilizer Co., Jacksonville, Fla.	C. A. Wilson, Deckertown.

Station Number.	SAMPLE OF	POUNDS PER HUNDRED OF Water.	Crude Fat.	Crude Fiber.	Crude Protein.	Crude Ash.	Carbohydrates.	Albuminoid Nitrogen.	Nitrogen.	Phosphoric Acid.	Potash.
827	Scarlet Clover, Green......	90.28	0.38	1.60	2.21	0.99	4.54	0.25	0.35	0.08	0.30
828	" " "	88.04	0.46	1.96	2.85	1.42	5.27	0.32	0.46	0.15	0.38
831	" " "	84.76	0.51	4.41	2.76	1.20	6.36	0.32	0.44	0.10	0.29
834	" " "	83.70	0.55	4.32	3.17	1.41	6.85	0.35	0.51	0.12	0.31
837	" " "	83.25	0.53	4.77	2.95	1.48	7.02	0.34	0.47	0.11	0.42
840	Cow Pea Vine	83.09	0.59	3.95	3.04	1.34	7.99	0.34	0.49	0.12	0.35
857	Corn Fodder.....................	46.20	1.31	13.35	5.61	3.52	30.01	0.76	0.90	0.39	0.76
853	Corn Stalks......................	37.63	0.89	18.95	6.08	5.23	31.22	0.83	0.97	0.38	0.87
854	Shelled Corn......................	25.37	3.99	1.65	8.94	1.42	58.63	1.38	1.43	0.61	0.34
855	Corn Cob............................	47.65	0.25	17.47	1.74	1.05	31.84	0.26	0.28	0.08	0.45
844	Sugar Beets (Kleinwanzleben)............................	81.32	0.05	1.11	1.75	1.07	14.70	0.11	0.28	0.12	0.45
845	Sugar Beets (Red Top)......	84.23	0.06	0.99	1.30	1.07	12.35	0.10	0.21	0.10	0.43
846	" " (Imperial).....	83.82	0.05	1.00	1.68	1.22	12.23	0.09	0.27	0.10	0.54
847	" " (Silesian)	78.71	0.07	1.32	1.76	1.25	16.89	0.13	0.28	0.16	0.48
848	Corn, Grain......................	13.03	3.89	1.49	9.55	1.43	70.61	1.52	1.53	0.69	0.33
849	Corn Meal	12.72	4.11	1.43	9.06	1.37	71.31	1.38	1.45	0.65	0.32
867	" "	13.30	3.88	1.45	9.33	1.42	70.62	1.41	1.49	0.64	0.40
842	Chicago Gluten Meal........	8.96	7.84	10.10	11.83	0.83	60.44	1.84	1.89	0.20	0.04
856	" " "	8.95	4.98	1.45	33.70	0.83	50.09	5.20	5.39	0.25	0.05
843	Buffalo Gluten Feed.........	8.62	12.83	7.20	19.54	0.93	50.88	3.13	3.13	0.35	0.09
852	Dried Brewers' Grains......	13.67	4.91	11.52	21.66	3.34	44.90	3.29	3.47	1.11	0.08
863	" " "	9.93	6.30	13.35	20.78	3.60	46.04	3.10	3.33	1.06	0.08
865	Wet Brewers' Grains.........	75.16	2.10	3.71	6.58	1.25	11.20	0.98	1.05	0.27	0.03
851	Wheat Bran	11.24	4.65	7.29	16.03	5.74	55.03	2.02	2.56	2.65	1.57
866	" "	10.63	5.15	6.51	16.29	5.51	55.91	2.08	2.61	2.73	1.40
811	Cotton-Seed Meal...............	9.23	9.39	5.31	41.94	7.53	26.60	6.65	6.71	3.74	1.99
858	" "	7.99	10.24	5.11	42.56	6.68	27.42	6.41	6.81	2.83	1.83
813	Linseed Meal, O. P...........	8.57	9.55	7.05	34.19	6.03	34.61	5.42	5.47	2.21	1.43
814	" " O. P..	9.63	6.65	7.09	36.56	5.74	34.33	5.73	5.85	2.37	1.35
850	" " N. P...........	10.76	3.37	7.89	34.88	5.62	37.48	5.19	5.58	2.12	1.38
812	Rice Polish.......................	9.50	11.21	3.32	14.31	6.28	55.38	2.23	2.29	3.29	1.19
815	Paine's Stock Feed..........	11.25	10.34	10.09	11.25	10.07	47.00	1.78	1.80	1.98	0.82

II.

MARKET PRICES OF COMMERCIAL FEEDS.

In 1891 a systematic effort was made to learn the average market price of commercial feeds used in the State. This work has been continued, and the average prices for three years are now compared. The quotations were made by large dealers in ten local centers of the State. The average quotations for the different dates, and the average for the six months preceding January 1st, each year, are here tabulated:

	1893.		1894.	Average for the Preceding Six Months.		
	Aug. 1.	Nov. 1.	Jan. 1.	1893-94.	1892-93.	1891-92.
Corn Meal, or Cracked Corn..	$21.17	$20.45	$19.84	$20.49	$21.65	$25.88
" and Cob Meal..............	21.00	21.00	21.00	21.00	....	....
Ground Oats..........................	28.10	27.60	27.20	27.63	30.17	24.25
Ground Corn and Oats, equal parts..............................	24.56	23.94	23.20	23.90	25.12	27.07
Gluten Meal..........................	23.00	25.00	25.00	24.33	27.00	22.50
Buffalo Gluten Feed............	20.50	20.00	20.00	20.17	20.00	....
" " Meal............	....	....	22.00	22.00	....	....
Chicago Feed.........................	18.00	19.00	19.00	18.67	17.67	....
Corn Bran..............................	17.00	17.00	16.75	16.92	15.83	18.00
Hominy Meal.........................	18.67	19.00	18.83	18.83	19.89	23.00
" Chops.........................	19.00	19.00	18.50	18.83	20.00	23.50
Wheat Bran............................	18.50	18.46	18.47	18.48	18.11	21.06
" Middlings, White......	21.39	21.18	21.00	21.19	21.08	25.50
" " Brown.....	19.06	18.94	18.63	18.88	18.65	22.75
" Shorts............................	18.00	20.00	20.00	19.33	18.33	26.00
Ship Stuff................................	17.75	17.50	17.50	17.58	17.67	27.50
Rye Bran.................................	20.00	19.50	19.00	19.50	18.50	19.50
" Middlings........................	21.50	21.00	20.00	20.83	20.07	24.00
Buckwheat Bran	11.00	11.00	11.00	11.00	11.00	12.00
" Middlings..........	19.00	19.00	19.00	19.00	17.50	19.00
Cotton-Seed Meal..................	27.75	27.33	27.38	27.49	27.75	28.00
Linseed Meal, Old Process ...	30.00	30.20	30.50	30.23	28.61	30.95
Malt Sprouts..........................	17.00	17.25	17.25	17.17	18.08	17.67
Dried Brewers' Grains..........	18.50	18.67	18.67	18.61	19.75	19.38

The prices for the six months preceding January 1st, 1894, are remarkably uniform. In the larger number of cases there has been a slight decline, though in no case has it reached 8 per cent. The increase, in a few cases, is also slight. The average prices for 1893–94 and 1892–93 are also much more uniform than was shown by a similar comparison last year. In eleven different feeds the average price is lower this year than last; the greatest decrease is in the case of oats, $21.53 per ton, or a little over 8 per cent. In ten feeds the prices are higher than in 1892–93; in these are included the bran and middlings from wheat and rye, though the prices of these grains were much lower this year than last. The greatest increase in price, $1.62 per ton, or 5.6 per cent., occurs in linseed meal.

Protein is still the cheapest food compound. This point, in connection with the fact that, as a rule, those feeds rich in protein are also relatively richer in the mineral fertilizing constituents, makes the right buying of feeds a matter of considerable financial importance, both to dairymen and general farmers.

III.

HOW SHALL FARMERS BEST DISPOSE OF THEIR PRODUCE?

CORN STALKS AND STRAW AS HAY SUBSTITUTES.

The problems relating to the feeding of animals are of great importance, and the investigation of certain of them has formed a considerable part of the work of this Station, the results of which have been published from time to time, both in bulletin form and in the annual reports. The object of this discussion is, therefore, not to report the work of recent investigations, but to restate facts and principles already well established; to furnish suggestions in reference to the proper use of farm produce, the buying of feeds, and the preparation of rations. It is believed that this work will be of value, since farmers are constantly brought face to face with the practical bearings of scientific principles in the matter of feeding.

OBJECT OF FEEDING.

Feeds may accomplish two objects—1. Maintenance of life, or 2. Maintenance of life, plus an increase of animal product, the latter of which, according to the kind of animal, may take the form of

flesh, fat, milk or work. To accomplish either of these objects the food must possess bulk, palatability and digestible nutritious compounds.

To maintain life, no special attention to these characteristics is required on the part of the feeder; to secure the additional animal product attention to them becomes of the greatest importance. Information that will prove of the most immediate usefulness would seem to be that which concerns—1. Hay substitutes, and 2. The use of these substitutes with feeds in the preparation of rations.

HAY SUBSTITUTES.

Hay possesses those peculiarities of bulk and nutritious compounds which make it particularly useful in accomplishing the first object of feeding, viz , maintenance of life, but lacks in concentration of nutritive matter, and therefore is not the most useful in accomplishing the second object—rapid increase in animal product. This useful characteristic, bulk, is nothing more nor less than indigestible matter, made up largely of the woody part of the hay. The digestible compounds of the hay are identical in kind with those contained in more concentrated products. Hay as hay, then, is not so important, provided we can secure the desired bulk and nutrition from other sources. The question of substitutes for hay, therefore, resolves itself into a question *of equivalents;* not in the sense that any product may be an exact equivalent in all respects when fed in the same way, but that other products may be used in such a manner as to secure an equivalent result.

M. Viger, the French Minister of Agriculture, in a circular recently issued, and called forth by the failure of the hay crop, says: "Now that hay has risen to its present price, this commodity can only be obtained by those who keep animals for pleasure. The farmer cannot buy forage at present prices; yet it is an error to suppose that animals on the farm are condemned to suffer or perish if the hay crop fails, for there are countries where horses and cattle never receive any hay, and these countries are renowned for their cattle." He also gives equivalents of nutritive materials of various commodities for cattle, compared to 100 pounds of hay, a number of which are as follows: "100 pounds of hay, of good average quality, can be replaced by either 170 pounds of oat straw, 237 pounds of wheat straw, 150 pounds of husks of oats, 193 pounds of wheat

chaff, 150 pounds of fresh leaves (poplar, ash, acacia, mulberry, oak, lime and elm), 80 pounds of dried leaves of the same, gathered when green; 275 pounds of pine leaves, 145 pounds of potatoes, 300 pounds of forage beet, etc." And in the matter of rations for maintenance, assuming 20 pounds of hay per day as providing the necessary nourishment for a horse of 1,000 pounds live weight, equivalent rations are: "*a.* 12 pounds of hay, 5 pounds of oats; *b.* 6 pounds of wheat straw, 8 pounds of oats; *c.* 16 pounds of green leaves, 2 of straw, 3 of oats and 2 of wheat; *d.* 16 pounds of green leaves, 2 of straw, 2 of oats and 2 of barley."

These statements are valuable, not only in giving equivalents in nutrition, but in showing the wide range of vegetable products that may serve as substitutes for hay. They are actual substitutes mainly in furnishing the desired bulk, for it must be remembered that while these products in the amounts given may furnish the equivalent of nutrition, it does not follow that they would serve equally well in maintaining life if fed alone; that is, no amount of straw is an exact equivalent of a definite amount of hay, both in the kind and proportion of the nutritive compounds, fat, protein and carbohydrates, because of the differences in chemical composition.

The protein of a feed corresponds to the lean meat of the animal body, and to the casein of the milk, and serves as a direct source of these products in the body; the fat corresponds to the fat of the body, and the butter fat of the milk, and serves as a source of these products, as well as aiding in the maintenance of animal heat and energy; the carbohydrates serve chiefly for the production of animal heat and energy, though under certain conditions are capable of conversion into fat.

The protein in straw and other coarse products after digestion is, pound for pound, quite as valuable, and serves its purpose quite as well as that contained in hay; this is also true of the other compounds, fat and carbohydrates, but in the straw the carbohydrates exist in much greater proportion to the others than in the hay, while the fat and protein are in less proportion, and all are combined with a larger amount of the indigestible woody matter in the straw than in the hay, thus rendering the digestion more difficult.

It is interesting, however, to note the extent to which this matter of the utilization of what may be regarded as the least valuable parts of our farm crops or other vegetable products, as substitutes for hay, has been studied, and the value that is now attached to them in those

countries where they are used, and profitably converted into valuable animal product. How much more important must be the proper preservation and use of our more valuable farm products, like corn stalks and straw, now so carelessly handled and wastefully used, and which experimental tests have shown to contain almost as much nutriment, ton for ton, as meadow hay. In our own State, therefore, there seems to be no special necessity of giving our attention to the less valuable products until greater care is exercised in the use of corn stalks and straw. These, for us, are the chief substitutes for hay. In the case of straw many farmers insist that aithough it may possess feeding value, it is more useful as bedding and manure than as feed. Straw has a decided value for these purposes, but if farmers recognized that straw trodden into the mire of an open yard is not good bedding, and that the resultant product is not good manure, there would, in the majority of instances, be a considerable quantity left for feed, after the legitimate uses of bedding were served.

Since two of the characteristics of a feed, bulk and nutriment, are contained in these coarse products, and they are, therefore, hay substitutes, in so far as they aid in accomplishing the first object of feeding—maintenance of life—the real question comes on how to use them in order that they may best aid in the second object—increase in animal product.

FEEDS TO BE USED WITH HAY SUBSTITUTES.

It has already been shown that a feed is a feed because it contains elements or compounds corresponding in kind to those contained in the animal body, which the animal organism is capable of converting into materials that sustain life, and thus increase their product. A feed is *good* when it is eatable, and when it contains a high content of the more valuable constituents, though a good feed is not equally good for all purposes, because of the various products derived from feeding, and because even animals of the same kind differ in their capacities for using feeds. A best feed is one which accomplishes most economically the object in any particular case. It follows, therefore, that the best use of a feed is that which best meets the needs of the animals for any special purpose.

These points have been carefully investigated and have given rise to what are termed feeding standards, or proportions of digestible fat, protein and carbohydrates best adapted to the various purposes of

feeding. Feeding standards and their usefulness as guides in the matter of feeding, have been fully discussed in our previous reports, now in the hands of farmers, and are referred to here mainly to indicate the principles which underlie the combinations of fodders and feeds in the rations that may be suggested. It has already been stated that hay, stalks, straw and other coarse fodders consisted largely of carbohydrates, a class of nutrients not calculated to cause a rapid increase in flesh or a large flow of milk. To insure an economical production of these, such farm products must be combined with others, rich or richer in protein and fat, thus approaching a proper balancing of food compounds for specific purposes.

Feeds rich in protein and fat, and thus able to supply the deficiency in this important respect, are, in the order of their content of protein, cotton-seed meal, linseed meal, gluten feed, malt sprouts, buckwheat middlings, dried brewers' grains, wheat middlings and wheat bran. Corn meal should also be mentioned here, for it is one of the best of feeds, although it is not calculated to balance the coarser products of the farm, because of its high content of the same class of nutrients, carbohydrates. The same is also true, though in a less degree, of hominy meal, rice bran, and cerealine feed.

RELIABILITY OF COMMERCIAL FEEDS.

The chemical composition of these feeds may be found in Bulletin 87, which was distributed to the farmers of the State in April, 1892. The samples analyzed and reported in that bulletin were secured from ten local commercial centers, and fully represented the products for sale in the State; the results showed that feeds of the same kind, with one exception, were uniform in character, and that all were free from foreign impurities. This is an important fact, since many farmers fear that they cannot tell what they are buying, and that bran and middlings particularly often contain undue proportions of sweepings and dirt from the mills, and hence they hesitate to buy that which may prove injurious to their animals. The evidence gathered by the work of the Station is, that farmers may place reliance upon the uniformity and purity of these products in the hands of reliable dealers, though they should in all cases demand a statement as to the character of those with which they are unfamiliar.

A detailed tabulation of the average composition of feeds may also be found in the tables beginning on page 174 of this report.

PRICES OF FEEDS.

The average price per ton for the six months preceding January 1st, 1894, are shown in the table on page 162. At these prices, or slight variations from them, any one of the feeds will furnish the important constituents, protein and fat, at a less cost per pound than grain, which is now so low. Farmers need not hesitate, therefore, to sell their wheat and oats at present prices, for while they are excellent feeds, they are, for the purpose of utilizing coarse farm produce, less desirable and more expensive than the residues resulting from various manufactures.

These concentrated products have been shown to possess a high rate of digestibility, and to give fairly equivalent results if used in not too large amounts in well-balanced rations. Which one of the many to buy is, then, not so important a question as that of a sufficiency of them, when economy in feeding is alone considered; one feed may be relatively cheaper than another for a specific purpose or in particular cases, yet for general purposes, and in order that animals may have a variety, it is good economy to have a number on hand. Among dairymen this practice is followed, but where small herds are kept, it is not so general as it should be. It is claimed that small lots are expensive, and local dealers do not have a large variety in stock. This claim is true, yet this difficulty may be overcome by a number of farmers combining and ordering large lots. Car-load lots may be secured through their dealers at much cheaper rates than ton lots, and a car lot could be easily distributed in a neighborhood.

FERTILITY IN FEEDS.

The buying of concentrated feeds should also be studied from the standpoint of fertility. The farmer's capital stock is fertility, the main elements of which are nitrogen, phosphoric acid and potash; these, through the agency of plants, are converted into products which have a fertilizing value, regardless of market price; that is, if corn, oats, wheat or hay are returned to the land, they will aid in the growth of other plants by virtue of the manurial elements contained in them. The average amounts of these constituents in the four principal farm crops are shown in

TABLE 1.

	Pounds per ton of Nitrogen.	Pounds per ton of Phosphoric Acid.	Pounds per ton of Potash.
Wheat	38	20	11
Oats	37	15	12
Corn	33	12	7
Timothy hay	20	7	26

These amounts per ton of fertilizer constituents are removed from the farm when the grain and hay are sold. When feeds are bought it is important to know whether anything is gained in fertility by the exchange, for under equivalent conditions of feeding the same relative amounts of fertilizer constituents are retained in the animal products. Table 2 shows the amounts of fertilizer constituents contained in the more concentrated feeds.

TABLE 2.

	Pounds per ton of Nitrogen.	Pounds per ton of Phosphoric Acid.	Pounds per ton of Potash.
Cotton-seed meal	139	65	38
Linseed meal	109	42	29
Gluten feed	76	8	1
Malt sprouts	88	33	37
Buckwheat middlings	80	43	23
Dried brewers' grains	77	19	2
Wheat middlings	56	42	21
Wheat bran	50	60	31

It is observed that all of these feeds greatly exceed the grain and hay in nitrogen, and with the exception of gluten feed and dried brewers' grains, the mineral constituents are also in considerable excess. When market prices are such as to make the exchange of farm produce for commercial feeds a judicious proceeding from the feed standpoint, the inevitable result will be a decided gain to the farm in fertility. Farmers of this State spend $1,500,000 annually for these identical constituents of fertility in the shape of commercial fertilizers, and many thousands of dollars more for city stable manure. These facts furnish sufficient evidence that an increased fertility is desired. A closer attention to this matter of manurial values in feeds would either materially reduce the expense now incurred in these directions, or secure a greater increase in fertility at the same expense, for market prices of feeds are not influenced by manurial values.

This matter cannot be urged too strongly, particularly where fer-

tility must be imported to the farms in order that maximum crops may be secured. In our exports of linseed meal, and in the bran and middlings contained in the whole wheat exported, farmers in other countries are now given annually an amount of fertility that would cost us, if bought in other forms, not less than $16,000,000. This amount of fertility, gathered largely from the rich stores of our Western States, should be retained for the less fertile lands of the East. It will be retained only when farmers have learned to apply more fully those principles which govern the economical use of fodders and feeds, the results of which are a saving of food and of fertility. Finished farm products only should be exported.

PREPARATION OF RATIONS.

The first point of importance in the preparation of a ration, bulk and essential nutrients being present, is palatability. The food must be of such a character as to induce a maximum consumption of actual nutrients, because profit in feeding for the production of milk, flesh or fat, lies in the excess of feed consumed over that necessary to maintain life. Corn stalks and straw in their original state are not readily and completely eaten by animals. To insure the minimum waste they must be cut, and the coarser and finer portions intimately mixed, and feeds of known relish added. In England, where great progress has been made in feeding methods, the cut hay, straw and other coarse products are mixed with sliced roots, the feeds added, the whole mass thoroughly mixed and allowed to remain some time before feeding. This method doubtless adds to both the palatability and digestibility of the foods, and it is to be recommended where circumstances permit. This matter of preparation, however, gives rise to the question, Will it pay farmers to invest in machinery for this purpose? For dairy farmers, there can be no question as to the advisability of such a course, since in feeding corn stalks, whole, in the usual manner, from one-third to one-half of the food contained in them is wasted. Where few animals are kept, and simple maintenance is desired, if this is ever desirable except in the case of work horses in winter, it becomes a question worthy of some consideration, though an increase of feed equivalent to two or three tons of hay at present prices would pay for a good fodder cutter; one good cutter might serve, too, for several farmers in a neighborhood until the usefulness of the cutter was thoroughly tested.

A few rations are here given which contain the fodders and feeds in good proportions, and which permit of a wide use of corn stalks and straw, as substitutes for timothy hay. These are intended in all cases to be sufficient for a daily feed for one thousand pounds live weight of animal under average conditions, and may serve a useful purpose as guides in the matter of amount and proportion of the nutrients. They are not intended as positive rules; animals must be fed as individuals with peculiarities of appetite, digestion and assimilation, not as fixed machines. The rations given have in all cases, too, the merit of having been tried with entire satisfaction, a number at the College farm, and others by practical dairymen in the State. Nos. 1 and 2 for horses have been fed in an experiment on horse-feeding at the College farm since June 1st, and, so far, are giving very gratifying results. A large amount of hay seems unnecessary, and other feeds may substitute oats.

It is not expected that these suggestions will meet all cases, and if those farmers whose conditions are different, or who desire to use smaller quantities, particularly of the concentrated feeds, than is here recommended, will address the Station, giving full details in reference to kind of animals, feeds and fodders obtainable, and object of feeding, their inquiries will receive careful attention.

Rations for Dairy Cows.

No. 1.	No. 2.	No. 3.
10 lbs. corn stalks.	6 lbs. clover hay.	10 lbs. corn stalks.
3 " corn meal.	8 " oats straw.	5 " wheat straw.
3 " hominy meal.	4 " corn meal.	4 " dried brewers' grains.
6 " wheat bran.	4 " malt sprouts.	3 " wheat bran.
2 " cotton-seed meal.	3 " wheat bran.	2 " corn meal.
8 " roots.	3 " linseed meal.	2 " cotton-seed meal.
No. 4.	**No. 5.**	**No. 6.**
40 lbs. corn ensilage.	6 lbs. corn stalks.	10 lbs. corn fodder.
6 " malt sprouts.	6 " clover hay.	7 " dried brewers' grains.
4 " wheat middlings.	6 " corn meal.	5 " corn meal.
2 " linseed meal.	7 " dried brewers' grains.	1 " cotton-seed meal.
No. 7.	**No. 8.**	**No. 9.**
8 lbs. corn stalks.	6 lbs. clover hay.	12 lbs. clover hay.
8 " oats straw.	6 " wheat straw.	5 " wheat bran.
3 " gluten feed.	5 " corn meal.	5 " ground oats.
3 " dried brewers' grains.	3 " malt sprouts.	5 " corn meal.
5 " buckwheat middlings.	3 " gluten feed.	
	3 " linseed meal.	

Rations for Horses.

No. 1.	No. 2.	No. 3.
8 lbs. timothy hay.	8 lbs. timothy hay.	6 lbs. clover hay.
6 " dried brewers' grains.	6 " corn.	4 " corn stalks.
6 " corn.	5 " wheat bran.	6 " corn.
	1½ " linseed meal.	4 " wheat bran.
		1 " linseed meal.

No. 4.	No. 5.	No. 6.
4 lbs. clover hay.	6 lbs. timothy hay.	6 lbs. timothy hay.
8 " wheat straw.	10 " corn stalks.	8 " oats straw.
5 " corn meal.	2 " wheat bran.	3 " wheat bran.
5 " wheat bran.	2 " corn meal.	2 " corn meal.
2 " linseed meal.		

For Fattening Steers.

No. 1.	No. 2.	No. 3.
10 lbs. corn stalks.	5 lbs. clover hay.	10 lbs. corn stalks.
5 " clover hay.	10 " oats straw.	8 " wheat straw.
6 " corn meal.	6 " corn meal.	6 " gluten feed.
5 " wheat bran.	6 " wheat bran.	5 " corn meal.
3 " cotton-seed meal.	3 " linseed meal.	3 " cotton-seed meal.

In these rations four pounds of wet brewers' grains may be substituted for one of dried grains, and ground corn and cob meal may substitute corn meal pound for pound without materially affecting the rations; buckwheat bran, free from hulls, may also substitute buckwheat middlings. The rations for dairy cows are intended for full flow of milk; for cows approaching the calving period, the feeds should be reduced and coarse fodders increased. Rations 1, 2, 3 and 4 for horses are intended for moderate work, the others for simple maintenance, and perhaps will apply equally well for cattle; both cattle and horses will gain in weight on liberal rations of clover hay. Where stock is kept, clover hay should not be sold from the farm. For young and growing stock, as calves and colts, linseed meal, bran and middlings are the best additions to the rough fodders, stalks and straw, in the way of feeds, as they are rich in the muscle and bone-forming constituents; the amounts required should be adjusted by the feeder according to the age of the animals.

Where farmers have not the appliances for making weights at each feed, and prefer to measure, the different materials should be weighed at least once, and the relation between a certain weight and a certain bulk ascertained. The weights of feed for a day's ration for a herd may be mixed together in the proportions given, and in feeding they should be distributed in such a way as to give animals of different

live weights and capacities for using food that amount best adapted for them. Where there are a number of dry cows in the dairy, then the mixtures for each lot had best be made separately. For horses the rations for work and maintenance may each be mixed in considerable quantities and placed in separate bins.

IV.

AVERAGE COMPOSITION OF FODDERS AND FEEDS.

The very large increase in the number of analyses of fodders and feeds, in recent years, has contributed much to our knowledge of their composition; these increased data make it necessary to revise such averages as have been published in our reports in the past, and which were derived largely from our own analyses. The averages in the following tables have been largely taken from the compilations made by Dr. E. H. Jenkins and Mr. A. L. Winton, and reported in Bulletin No. 11 of the Office of Experiment Stations. In many cases the analyses made at this Station since that report was issued, particularly of the commercial feeds, have been included in the averages. The average analysis of corn stalks, as derived from the analyses made at this Station, is also included, since it represents more nearly the composition of the stalks as fed in this State.

The tables also show the average amounts of the digestible constituents in each feed, as derived from the best data available, and the "nutritive ratio" derived by multiplying the digestible fat by $2\frac{1}{2}$, thus converting it into terms of carbohydrates, adding this amount to the digestible carbohydrates, and dividing by the percentage of digestible protein.

Although the per cent. of the fertilizer constituents, nitrogen, phosphoric acid and potash, accompanies each food analysis, another table is constructed, in which is shown the amounts of these constituents contained in a ton of the principal farm crops and commercial feeds. The content of fertilizing elements, particularly the mineral constituents, has no special reference to the usefulness of any product as a feed, but rather to the character and composition of the manure derived from feeding it; to the loss in fertility that follows the sale of farm produce, and the loss or gain that follows the exchange of farm produce for commercial feeds. This matter has already been referred to in preceding pages; it is of great importance, and should be carefully studied by all farmers.

Number of Analyses.	KIND OF FEEDING STUFF.	PERCENTAGE COMPOSITION.					
		Water.	Crude Fat.	Crude Fiber.	Crude Protein.	Crude Ash.	Carbohydrates.
	GREEN FODDERS AND SILAGE.						
17	Pasture Grass	70.3	1.2	6.5	4.7	2.8	14.5
4	Orchard Grass, in bloom	73.0	0.9	8.2	2.6	2.0	13.3
56	Timothy	61.6	1.2	11.8	3.1	2.1	20.2
	Corn (Maize) Fodder:						
40	Flint varieties	79.8	0.7	4.3	2.0	1.1	12.1
63	Dent varieties	79.0	0.5	5.6	1.7	1.2	12.0
21	Sweet varieties	79.1	0.5	4.4	1.9	1.3	12.8
43	Red Clover	70.8	1.1	8.1	4.4	2.1	13.5
4	Alsike Clover, in bloom	74.8	0.9	7.4	3.9	2.0	11.0
23	Alfalfa (Lucern)	71.8	1.0	7.4	4.8	2.7	12.3
11	Cow Pea	83.5	0.4	4.7	2.5	1.7	7.2
11	Sorghum (whole plant)	79.4	0.5	6.1	1.3	1.1	11.6
7	Rye Fodder	76.6	0.6	11.6	2.6	1.8	6.8
5	Oat Fodder	62.2	1.4	11.2	3.4	2.5	19.3
99	Corn (Maize) Silage	79.1	0.8	6.0	1.7	1.4	11.0
	HAY AND DRY COARSE FODDERS.						
35	Corn (Maize) Fodder	42.2	1.6	14.3	4.5	2.7	34.7
15	Corn (Maize) Stalks	68.4	0.5	11.0	1.9	1.2	17.0
7	Corn (Maize) Stalks*	10.2	1.2	28.2	4.6	5.2	50.6
11	Hay, Mixed Meadow Grasses	16.0	2.1	29.9	6.4	4.6	41.0
70	Timothy Hay	13.6	2.5	28.9	5.9	4.4	44.7
12	Hay, Hungarian Grass	7.7	2.1	27.7	7.5	6.0	49.0
38	Red Clover Hay	15.3	3.3	24.8	12.3	6.2	38.1
9	Alsike Hay	9.7	2.9	25.6	12.8	8.3	40.7
21	Alfalfa (Lucern) Hay	8.4	2.7	25.0	14.3	7.4	42.7
7	Wheat Straw	9.6	1.3	38.1	3.4	4.2	43.4
7	Rye Straw	7.1	1.2	38.9	3.0	3.2	46.6
12	Oat Straw	9.2	2.3	37.0	4.0	5.1	42.4
	ROOTS AND TUBERS.						
9	Mangels	90.9	0.2	0.9	1.4	1.1	5.5
4	Rutabagas	88.6	0.2	1.3	1.2	1.2	7.5
3	Turnips	90.5	0.2	1.2	1.1	0.8	6.2
9	Red Beets	88.5	0.1	0.9	1.5	1.0	8.0
19	Sugar Beets	86.5	0.1	0.9	1.8	0.9	9.8

* New Jersey samples.

PER CENT. OF DIGESTIBLE MATTER.			Nutritive Ratio. 1 :	PER CENT. OF FERTILIZER CONSTITUENTS.		
Crude Fat.	Crude Protein.	Carbohydrates, including Fiber.		Nitrogen.	Phosphoric Acid.	Potash.
0.8	3.5	16.2	5.2	0.75	0.19	0.60
0.6	1.8	15.5	9.4	0.41	0.22	1.29
0.6	2.0	21.1	11.3	0.50	0.30	0.88
0.5	1.5	11.2	8.3	0.32	0.15	0.33
0.4	1.2	12.1	10.9	0.27	0.15	0.33
0.4	1.4	11.7	9.1	0.30	0.15	0.33
0.7	2.9	13.3	5.2	0.70	0.19	0.67
0.6	2.6	11.3	4.9	0.63	0.15	0.28
0.6	3.2	12.2	4.3	0.77	0.15	0.64
0.1	1.7	7.2	4.4	0.40	0.08	0.24
0.4	0.8	12.7	17.1	0.21	0.10	0.27
0.5	2.1	14.0	7.3	0.41	0.09	0.45
1.0	2.7	22.4	9.2	0.54	0.13	0.38
0.6	1.2	11.8	11.1	0.27	0.11	0.37
1.2	3.3	33.5	11.1	0.72	0.34	0.56
0.4	1.4	19.3	14.5	0.30	0.08	0.35
0.9	3.4	54.2	16.6	0.73	0.23	0.99
1.0	3.6	42.9	12.6	1.02	0.26	1.48
1.2	3.3	44.6	14.4	0.94	0.33	1.42
1.0	4.2	46.7	11.4	1.20	0.35	1.30
2.0	7.7	39.2	5.7	1.98	0.36	2.10
1.7	8.1	41.4	5.6	2.05	0.67	2.23
0.9	11.0	37.8	3.7	2.29	0.50	1.65
0.4	0.8	37.2	47.8	0.50	0.09	0.72
0.4	0.8	38.6	49.5	0.48	0.29	0.79
0.7	1.5	40.4	28.1	0.64	0.22	1.21
....	1.1	4.8	4.4	0.22	0.06	0.27
....	0.9	7.1	7.9	0.19	0.12	0.49
....	0.6	5.5	9.2	0.18	0.10	0.39
....	0.9	7.6	8.4	0.24	0.09	0.44
....	1.1	9.3	8.5	0.29	0.10	0.48

Number of Analyses.	KIND OF FEEDING STUFF.	PERCENTAGE COMPOSITION.					
		Water.	Crude Fat.	Crude Fiber.	Crude Protein.	Crude Ash.	Carbohydrates.
	ROOTS AND TUBERS—(*Continued*).						
8	Carrots	88.6	0.4	1.3	1.1	1.0	7.6
53	Potatoes	79.1	0.1	0.4	2.1	0.9	17.4
20	Sweet Potatoes	72.4	0.3	0.9	1.1	1.3	24.0
	GRAINS AND OTHER SEEDS.						
	Corn (Maize):						
68	Flint	11.3	5.0	1.7	10.5	1.4	70.1
86	Dent	10.6	5.0	2.2	10.3	1.5	70.4
26	Sweet	8.8	8.1	2.8	11.6	1.9	66.8
262	Wheat, Winter Varieties	10.5	2.1	1.8	11.8	1.8	72.0
6	Rye	11.6	1.7	1.7	10.6	1.9	72.5
30	Oats	11.0	5.0	9.5	11.8	3.0	59.7
8	Buckwheat	12.6	2.2	8.7	10.0	2.0	64.5
	MILL PRODUCTS AND REFUSE FEEDS.						
95	Corn (Maize) Meal	14.4	3.8	1.9	9.3	1.4	69.2
7	" and Cob Meal	15.1	3.5	6.6	8.5	1.5	64.8
3	" Bran	10.4	6.6	6.2	9.6	2.1	65.1
99	Wheat Bran, all analyses	11.7	4.1	8.9	15.4	5.9	54.0
13	" Shorts	11.7	4.5	7.0	15.1	4.4	57.3
41	" Middlings	11.8	4.0	4.4	15.7	3.2	60.9
10	" Screenings	11.6	3.0	4.9	12.5	2.9	65.1
9	Rye Bran	11.6	2.8	3.4	14.4	3.5	64.3
1	" Shorts	9.3	2.8	5.1	18.0	4.9	59.9
3	Buckwheat Bran	12.9	5.9	13.4	22.1	4.3	41.4
7	" Middlings	12.8	7.5	3.8	28.0	5.0	42.9
5	Rice Bran	9.7	8.8	9.5	12.1	10.0	49.9
8	Malt Sprouts	9.3	1.9	10.6	25.9	6.5	45.8
20	Brewers' Grains	75.7	1.7	3.7	5.9	0.9	12.1
20	" " Dried	8.8	6.5	13.2	22.5	3.8	45.2
32	Gluten Meal	9.6	6.3	1.6	29.4	0.7	52.4
12	Hominy Feed	11.1	8.3	3.8	9.8	2.5	64.5
43	Cotton-Seed Meal	8.0	12.9	5.6	42.3	7.2	24.0
28	Linseed Meal, old process	9.2	7.7	8.4	33.5	5.7	35.5
14	" " new process	10.1	3.0	9.5	33.2	5.8	38.4

PER CENT. OF DIGESTIBLE MATTER.			Nutritive Ratio. 1:	PER CENT. OF FERTILIZER CONSTITUENTS.		
Crude Fat.	Crude Protein.	Carbohydrates, including Fiber.		Nitrogen.	Phosphoric Acid.	Potash.
....	1.0	7.1	7.1	0.18	0 09	0.51
....	1.4	16.1	11.5	0.34	0.12	0.45
....	0.7	22.4	32.0	0.18	0.10	0.51
3.8	8.9	66.5	8.5	1.68	0.70	0.40
3.8	8.8	66.2	8.6	1.65	0.70	0.40
6.2	9.9	63.7	8.0	1.82	0.72	0.41
1.8	9.2	55.9	6.6	1.89	0.93	0.64
1.2	8.3	65.5	8.3	1.70	0.85	0.56
4.1	8.7	45.6	6.4	1.89	0.89	0.67
1.8	7.7	49.2	7.0	1.60	0.45	0.21
2.9	7.9	65.7	9.2	1.49	0.61	0.38
2.9	6.5	56.3	9.8	1.36	0.44	0.53
2.0	5.6	50.0	9.8	1.54	1.21	0.68
3.3	13.6	45.0	3.9	2.46	2.89	1.61
3.2	11.6	45.4	4.6	2.42	1.38	0.65
2.9	12.2	47.2	4.5	2.51	1.41	0.70
2.2	9.8	51.0	5.8	2.00	....	....
1.6	9.5	48.2	5.5	2.30	1.60	0.96
1.6	11.9	45.1	4.1	2.88	2.19	1.21
3.4	13.3	23.6	2.4	3.54	1.70	1.14
5.4	22.4	32.7	2.1	4.48	2.21	1.15
5.1	8.0	36.9	6.2	1.93	1.98	0.82
1.5	20.7	45.8	2.4	4.14	1.63	1.85
1.4	4.3	9.2	3.0	0.94	0.31	0.05
5.5	16.4	34.1	2.9	3.60	1.09	0.08
5.6	25.0	49.4	2.5	4.70	0.33	0.05
6.3	8.3	61.9	9.4	1.59	0.96	0.47
11.4	36.0	22.8	1.4	6.77	3.08	1.90
7.0	29.1	34.5	1.8	5.36	1.93	1.41
2.7	27.2	31.8	1.4	5.31	1.78	1.36

KIND OF FEED.	CONTAINED IN 2,000 POUNDS.		
	Nitrogen.	Phosphoric Acid.	Potash.
	lbs.	lbs.	lbs.
Corn Fodder	14.4	6.8	11.2
" Stalks (New Jersey)	14.6	4.6	19.8
Timothy Hay	18.4	6.6	28.4
Red Clover Hay	39.6	7.2	42.0
Scarlet Clover Hay	55.8	13.9	44.2
Alsike Clover Hay	41.0	13.4	44.6
Wheat Straw	10.0	1.8	14.4
Rye Straw	9.6	5.8	15.8
Oat Straw	12.8	4.4	24.2
Corn Kernels, Flint	33.6	14.0	8.0
" " Dent	33.0	14.0	8.0
Winter Wheat	37.8	18.6	12.8
Rye	34.0	17.0	11.2
Oats	37.8	17.8	13.4
Buckwheat	32.0	9.0	4.2
Corn Bran	30.8	24.2	13.6
Wheat Bran	49.2	57.8	32.2
" Middlings	50.2	28.2	14.0
Rye Bran	46.0	32.0	19.2
Buckwheat Bran	70.8	34.0	22.8
" Middlings	89.6	44.2	23.0
Malt Sprouts	82.8	32.6	37.0
Brewers' Grains	18.8	6.2	1.0
" " Dried	72.0	21.8	1.6
Buffalo Gluten Feed	69.8	7.4	1.6
Gluten Meal	94.0	6.6	1.0
Hominy Feed	31.8	19.2	9.4
Cotton-Seed Meal	135.4	61.6	38.0
Linseed Meal, old process	107.2	38.6	28.2
" " new process	106.2	35.6	27.2

FEEDING EXPERIMENTS WITH HORSES.

COLLEGE FARM, NEW BRUNSWICK, N. J.

In a study of rations for horses, carried out in connection with a feeding experiment last year, it was shown that the usual methods of feeding were not only irrational from the standpoint of actual nutrients provided, but that the more expensive food products, oats and timothy hay, furnished the bulk of the daily rations used.

The results of the experiments were positive in showing "that it was the kind and quality of specific nutrients that determined the value of a ration, rather than the names of materials;" that "while oats, for instance, were an excellent horse feed, it was not alone because they were oats, but because of the amount and proportions of the valuable nutrients, fat and protein, contained in them." In other words, when the substitution of other feeds for oats is made in such a manner as to make the daily ration contain the proper amount and proportion of the food constituents, the results were quite as satisfactory as when oats constituted the bulk of the ration. The experiments were also useful in indicating that the amount and proportion of the nutrients, fat and protein, suggested by the German standard for medium work, might be safely used as a guide in the preparation of rations.

The object of the experiment this year was to test the suggestions indicated in that experiment when applied to farm horses.

The difficulties surrounding an experiment of this kind, due mainly to a lack of uniformity in the work performed, were recognized in the beginning and were obviated, as far as possible, by a comparatively long feeding trial, and by a flexibility in the amount of the feed or concentrated part of the ration used, under the different conditions of work performed, *i. e.* whether light, medium or heavy work; the hay or bulky part of the ration remaining constant under all conditions of work.

PLAN OF THE EXPERIMENTS.

Four of the College farm horses, ranging in age from seven to ten years, and sound and healthy in every respect, were selected for the experiments, and numbered 1, 2, 3 and 4. Nos. 1 and 2 performed regular farm work only. No. 4 was used entirely on the milk route, while No. 3 performed general-purpose driving in connection with work on the milk route. The horses were divided into two lots. Lot 1 consisted of horses 1 and 3, and lot 2 included horses 2 and 4; each horse in a lot, therefore, performed a different kind of work, and one horse in each lot performed the same kind of work, because used entirely in a team. The following rations were used:

Lot 1.		Lot 2.	
Timothy hay	8 pounds.	Timothy hay	8 pounds.
Corn	6 "	Corn	6 "
Dried brewers' grains	6 "	Wheat bran	5 "
		New-process linseed meal	1½ "

These rations correspond with each other in containing the same amounts and proportions of the digestible food compounds, fat, protein and carbohydrates, differing only in the kind of materials furnishing the bulk of the protein. The feeds were mixed, and one-third of the mixed ration fed dry morning, noon and evening. In the beginning of the experiment, corn in the grain was used. This was, however, changed to ground corn during the first month because of the greater apparent relish for the latter. The hay was fed whole, in equal parts, morning and evening. The daily ration of hay was to be constant, while the feeds were to correspond in amount to the kind of work performed and to the weight of the horses, the proportions to be kept the same.

These rations practically correspond to those suggested in Bulletin No. 92, pages 17 and 18, as furnishing the proper proportions and amounts of fat and protein for a daily ration for a 1,000-pound horse on medium work. The hay is slightly increased because of the larger size of the horses and because of the lack of uniformity of the work performed by three of the four horses. The amount of hay was kept constant, in order that the changes in the amount of feeds given might result in a corresponding change in the nutritive ratio of the ration. The horses were carefully weighed once each week, under uniform conditions as to time of weighing.

The experiment proper—which continued throughout six months, from June 1st to December 1st, was preceded by a preliminary trial of one week in order to accustom the horses to the new rations. The amount of hay proved sufficient, and the whole ration was eaten quite as readily throughout the experiment period as could be expected.

The tables on pages 182 and 183 show the amounts of food eaten by each horse for each month during the experiment, the total amount consumed and the weights of the animals each week.

LOT NO. 1.—DRIED BREWERS' GRAINS RATION.

Horse No. 1.

MONTHS.	AMOUNT OF FOOD EATEN.			WEIGHT OF HORSE.						REMARKS.
	Hay.	Corn Meal.	Dried Brewers' Grains.	First.	Second.	Third.	Fourth.	Fifth.	Average for Months.	
	lbs.	lbs.	lbs	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	
June	240	219	219	1,150	1,115	1,125	1,110	1,120	1,124	The condition of this horse was good throughout the whole period of the experiment; the work was hard and the weather excessively warm during July and August. There were but three days when the full ration was not eaten.
July	248	230	215	1,090	1,080	1,100	1,075	....	1,086	
August	248	189	203	1,130	1,110	1,090	1,120	....	1,113	
September	240	180	180	1,075	1,085	1,125	1,060	....	1,086	
October	248	186	186	1,120	1,125	1,125	1,125	....	1,124	
November	240	180	180	1.125	1,130	1,135	1,125	....	1,129	
Total for 183 days	1,464	1,184	1,183	Average weight for six months					1,110	
Average daily ration	8.0	6.5	6.5							

Horse No. 3.

MONTHS.	Hay.	Corn Meal.	Dried Brewers' Grains.	First.	Second.	Third.	Fourth.	Fifth.	Average for Months.	REMARKS.
June	240	235	217	1,200	1,215	1,220	1,185	1,175	1,199	The condition of horse No. 3 was good and work regular until July 12th, when, owing to an injury to his leg, he was unable to perform hard work until the latter part of August. His appetite was also somewhat uncertain after the accident; he was the least satisfactory animal of the whole number. His general condition at the end of the experiment was, however, good.
July	248	244	183	1,200	....	1,175	1,190	....	1,188	
August	248	176	190	1,200	1,175	1,185	1,223	....	1,196	
September	240	180	183	1,175	1,170	1,210	1,225	....	1,195	
October	248	155	155	1,200	1,220	1,240	1,175	....	1.209	
November	240	135	135	1,175	1,170	1,175	1,125	....	1,161	
Total for 183 days	1,464	1,125	1,063	Average weight for six months					1,191	
Average daily ration	8.0	6.2	5.8							

LOT NO. 2.—WHEAT BRAN RATION.

Horse No. 2.

MONTHS.	AMOUNT OF FOOD EATEN. Hay.	Corn Meal.	Wheat Bran.	Linseed Meal.	WEIGHT OF HORSE. First.	Second.	Third.	Fourth.	Fifth.	Average for Month.	REMARKS.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	
June	240	135	154	46	1,130	1,115	1,115	1,110	1,125	1,119	The condition of No. 2 remained good throughout, though his appetite was seriously affected for a few days by the very hot weather of June and July—more so than any other of the animals. He did not eat his whole ration for nine days in June and ten days in July. His condition at the end of the experiment was much better that at the beginning.
July	248	238	173	39	1,105	....	1,100	1,075	....	1,093	
August	248	183	154	35	1,105	1,105	1,100	1,125	....	1,109	
September	240	173	144	43	1,110	1,118	1,115	1,125	....	1,117	
October	248	179	149	45	1,150	1,175	1,130	1,150	....	1,151	
November	240	173	144	43	1,150	1,165	1,190	1,185	....	1,173	
Total for 183 days	1,464	1,131	918	251	Average weight for six months					1,127	
Average daily ration	8.0	6.2	5.0	1.4							

Horse No. 4.

MONTHS.	Hay.	Corn Meal.	Wheat Bran.	Linseed Meal.	First.	Second.	Third.	Fourth.	Fifth.	Average for Month.	REMARKS.
June	240	232	191	57	1,270	1,245	1,225	1,225	1,220	1,237	The condition and appetite of horse No. 4 was good throughout; his work was practically identical every day of the experiment, which doubtless accounts, in large measure, for his uniformity. As in the other cases, less food seemed to be required during the fall months than during the hot weather of June and July.
July	248	269	214	61	1,210	1,250	1,225	1,200	....	1,221	
August	248	199	188	50	1,215	1,195	1,225	1,225	....	1,215	
September	240	203	169	51	1,225	1,195	1,200	1,225	....	1,211	
October	248	179	149	45	1,230	1,235	1,225	1,235	....	1,234	
November	240	173	144	43	1,235	1,230	1,260	1,225	....	1,238	
Total for 183 days	1,464	1,255	1,055	307	Average weight for six months					1,226	
Average daily ration	8.0	6.9	5.8	1.7							

The food consumed was greatest in each case during the month of July. The only variation in the proportions of grain used in the ration also occur in that month, due to the fact that during those times, as indicated in the remarks, when the animals did not eat well, they were fed larger proportionate amounts of those kinds more eagerly eaten.

Although lot No. 2 consumed slightly the largest amount of food, the average amount of nutrients consumed for 1,000 pounds live weight was practically identical for each lot.

GAIN OR LOSS IN WEIGHT.

The weights of the animals remained remarkably uniform. The difference between highest and lowest did not exceed seventy-five pounds in any case, the lowest recorded occurring in July, except for horse No. 3, whose final weight was the lowest. The average weight for the six months is practically identical in all cases with the average weight of the first month, though it is lower in all cases than the first weight recorded and is uniform for both lots.

The uniformity in the amount of the food consumed and in the weight of the animals, in connection with the work performed, indicates no material difference in the usefulness of the two rations used. Both were entirely satisfactory.

COST OF THE RATIONS.

The actual cost per ton of the respective feeds used in the experiment this year was, timothy hay, $18; wheat bran, $17.50; corn meal, $22; dried brewers' grains, $17, and linseed meal, $29. The amount and cost of the feeds consumed by each of the four horses for the period of 183 days are shown below:

Dried Brewers' Grains Ration.

HORSE NO. 1.

	Lbs.	Cost.
Timothy hay	1,464	$13.17
Corn meal	1,184	13.02
Dried brewers' grains	1,183	10.03
Total cost for 183 days		$36.22

Cost per day, 19.8 cts.

HORSE NO. 3.

	Lbs.	Cost.
Timothy hay	1,464	$13.17
Corn meal	1,125	12.38
Dried brewers' grains	1,063	9.04
Total cost for 183 days		$34.59

Cost per day, 18.9 cts.

Wheat Bran Ration.

HORSE NO. 2.	Lbs.	Cost.	HORSE NO. 4.	Lbs.	Cost.
Timothy hay	1,464	$13.17	Timothy hay	1,464	$13.17
Corn meal	1,131	12.42	Corn meal	1,255	13.80
Wheat bran	918	8.13	Wheat bran	1,055	9.23
Linseed meal	250	4.35	Linseed meal	305	4.42
Total cost for 183 days		$38.07	Total cost for 183 days		$40.62
Cost per day, 20.8 cts.			**Cost per day, 22.3 cts.**		

The following tabulation will show the comparison in cost between the dried brewers' grains and wheat bran rations, as actually fed, and also on the basis of 1,000 pounds weight of animal:

	Cost per Day, cts.	Cost per Day per 1,000 pounds Live Weight, cts.
Ration of horse No. 1	19.8	17.8
" " " " 3	18.9	15.9
" " " " 2	20.8	18.4
" " " " 4	22.3	18.2

It is observed that the cost of the daily rations used is much less than is ordinarily charged for feeding work horses. On the basis of 1,000 pounds live weight, the average cost per day for lot No. 1 is 16.85 cents, and for No. 2, 18.30 cents, that is, for the six hardest working months of the year a farm horse of 1,000 pounds live weight, may be fed for $30.84, when dried brewers' grains furnish the bulk of the necessary protein, and for $33.49, when wheat bran and linseed meal are the chief sources of this nutrient; on the basis of actual cost of the rations only, the brewers' grains ration is slightly more satisfactory, or 8.6 per cent. cheaper than the wheat bran ration. When the fertility value of the dried grains, wheat bran and linseed meal is regarded as of importance, the differences in the rations are less marked.

The value of the fertilizer constituents contained in the amounts of wheat bran and linseed meal eaten during the period is $18.73, that of the dried brewers' grains is $14.55, a difference in favor of the bran and linseed of $4.18; the fertility value is, however, positive only when the manure is all retained upon the land—a matter not easily accomplished in the case of work horses.

In Bulletin No. 92 it was stated that careful inquiry indicates that the following tabulation of rations would represent average conditions:

No. 1	hay, 12 pounds;	oats,	12 pounds.
" 2	" 12 "	corn, 6	12 "
" 3	" 12 "	oats, 6	

Assuming that the feeding of these rations would result in entire satisfaction, as was the case with those in the experiment, their cost per day, at the prices of feeds used in the above calculations, and oats at 35 cents per bushel, which is a minimum price, would be for No. 1, 23 cents; No. 2, 24.4 cents, and No. 3, 24.8 cents; and for the six months, $42.10, $44.65 and $45.38, respectively, or a cost of from 36.5 per cent. to 47.1 per cent. greater than that of the ration used for lot No. 1.

The rations used in the experiments do not require an elaborate mixture of feeds, are as simple in their preparation as those ordinarily used, and include feeds that are readily purchasable, hence the main difference in their feeding over those ordinarily fed on grain farms is, that certain home-grown products shall be exchanged for them.

Where it is necessary to purchase all of the feeds, as is often the case in the market-garden or fruit-growing districts, the lower cost of the rations is not thus modified. These rations, too, have a higher fertility value than those prepared entirely from home-grown produce.

The savings effected by the use of these rations, or those similar, in that they contain the same kind and proportion of nutrients drawn from economical sources, are also actual. Mr. J. M. White, a prominent and successful horticulturist of New Brunswick, who is obliged to buy a large part of his feeds, used during the past season a ration similar to that fed to lot No. 1. He reports that the results were eminently satisfactory; that his horses never looked better, and that his actual saving on his feed bills during the year was $150 for eight animals, or about twenty per cent. The animals included two colts not receiving full rations. In other words, he gained enough to purchase five tons of a high-grade commercial fertilizer, the liberal and intelligent use of which is largely responsible for his success as a fruit-grower. Other farmers in the vicinity of the Station, as well as in more remote districts, report very satisfactory results, though they have not kept accurate records as to the amount of money actually saved. Testimony of practical men on these points is evidence, first, of the practicability of the rations; and second, that the gains indicated by the experiment may be actual gains. The cost of feeding the horses and mules on farms in this State—a total of 91,617, according to

recent statistics—probably reaches $3,500,000 for the six main working months of the year; a legitimate expense, provided the nutrients furnished have been no more than sufficient to properly nourish the animals, and provided the nutrients have been derived from the most economical sources. The evidence acquired, both from careful inquiry as to the kind of rations used, and from feeding experiments as to the kind and amount of food needed, indicates that this expense may be over thirty per cent. too great. In the case of an intelligent farmer, it was actually twenty per cent. on the basis of a year. Assuming that it is twenty per cent. too great now, the expense of feeding the horses of the State for the six working months would be reduced by $700,000 if more rational methods were adopted. The results secured from the feeding trials conducted by the Station warrant it in strongly urging the farmers of the State to make a practical trial of the rations fed in the experiment this year, and in emphasizing the following suggestions contained in Bulletin No. 92:

"1. That at the present time too little attention is paid to the preparation of rations for work horses. Rational feeding is quite as important for horses as for dairy cows.

"2. That the kind and quality of specific nutrients contained in feeds, and not their names, should guide in the preparation of rations.

"3. That while oats are an excellent horse feed, it is not alone because they are oats, but because of the amounts and proportions of the more valuable nutrients, fat and protein, contained in them.

"4. That dried brewers' grains are a wholesome, nutritious and palatable horse feed, and at present prices they may be substituted for oats and a decided saving made in the cost of the ration.

"5. Timothy hay and oats, at present prices, are expensive feeds. It does not follow because a farmer raises these crops that he should feed them, when other products equally useful may be purchased at a less cost per pound of actual nutrients.

"6. The condition of the markets in this State furnishes abundant evidence that the selling price of fine feeds and farm products is not a correct basis for estimating actual feeding value.

"7. A farmer who intelligently exchanges farm products for commercial feeds, even at the same prices per ton, may secure not only an increase in feeding value, but also a gain in fertility. Market conditions do not recognize differences in the fertilizing constituents of feeds."

APPENDIX.

APPENDIX.

ACT OF INCORPORATION.

The New Jersey Agricultural Experiment Station was established by authority of the following acts of the Legislature of the State:

CHAPTER CVI.

An Act to provide for the establishmeet of an Agricultural Experiment Station.

1. Be it enacted *by the Senate and General Assembly of the State of New Jersey,* That for the benefit of practical and scientific agriculture, and for the development of our unimproved lands, the New Jersey Agricultural Experiment Station, with suitable branches, is hereby established.

2. *And be it enacted,* That the direction and management of this institution shall be committed to a Board of Directors, which shall consist of the Governor of the State, the Board of Visitors of the State Agricultural College, together with the President and the Professor of Agriculture of that institution.

3. *And be it enacted,* That the members of this Board shall be called together by the Secretary of the Board of Visitors, and shall organize by the election of a President and Secretary, who shall hold their offices for one year and until their successors are elected; five members shall constitute a quorum.

4. *And be it enacted,* That the Board of Directors shall hold a meeting each year at Trenton, on the third Tuesday in January, and other meetings at the call of the President, at such times and places as may best promote the objects of the institution.

5. *And be it enacted,* That the Board of Directors shall locate said Experiment Station and branches, and shall appoint a Director, who

shall have the general management and oversight of the experiments and investigations necessary to carry out the objects of said institution, and shall employ competent chemists and other assistants necessary to analyze soils, fertilizers and objects of agricultural interest, so as to properly carry on the work of the Station, and it shall make an annual report of its work to the Governor of the State.

6. *And be it enacted,* That a sum not exceeding five thousand dollars in any one year is hereby appropriated to said New Jersey Experiment Station, which money shall be paid out from the State Treasury on the presentation of the bills of said Station, properly certified by the President and Secretary of the Board of Directors.

7. *And be it enacted,* That this act shall take effect immediately.

Approved March 10th, 1880.

CHAPTER LXXXI.

A Supplement to the act entitled "An act to provide for the establishment of an Agricultural Experiment Station," approved March tenth, one thousand eight hundred and eighty.

1. Be it enacted *by the Senate and General Assembly of the State of New Jersey,* That from and after the passage of this act, the Board of Directors mentioned and created by said act shall be called and known as the Board of Managers.

2. *And be it enacted,* That in addition to the powers now conferred upon said Board, they shall have power to elect a Treasurer, who shall hold his office for one year and until his successor shall be elected and qualified; and to appoint such other officers and agents as may be necessary to carry on the business of the institution; and to make such rules, by-laws and regulations for the government of the Board, and for carrying out the objects, business and purposes of the institution, as may, in their judgment, be necessary and proper.

3. *And be it enacted,* That the annual appropriation for the support of the New Jersey Agricultural Experiment Station be and the same is hereby increased from its present sum of five thousand dollars a year to eight thousand dollars a year.

4. *And be it enacted,* That this act shall take effect immediately.

Approved March 9th, 1881.

CHAPTER CCVIII.

A Supplement to the supplement to an act entitled "An act to provide for the establishment of an Agricultural Experiment Station," approved March ninth, one thousand eight hundred and eighty-one.

1. Be it enacted *by the Senate and General Assembly of the State of New Jersey,* That section three of the supplement to the act entitled "An act to provide for the establishment of an Agricultural Experiment Station," be amended so as to read as follows:

3. *And be it enacted,* That the expenses of said Station, when presented to the Comptroller of the State, accompanied by the proper vouchers, duly certified by the President and Secretary of the Board of Directors, shall, upon warrant of said Comptroller, be paid out of the State Treasury; *provided,* such expenses do not exceed the sum of eleven thousand dollars in any year.

2. *And be it enacted,* That this act shall take effect immediately.

Approved May 9th, 1884.

CHAPTER CCCVII.

An Act to provide for the construction of a State Laboratory for the State Agricultural Experiment Station.

1. Be it enacted *by the Senate and General Assembly of the State of New Jersey,* That the sum of thirty thousand dollars be and hereby is appropriated for the construction of a State Laboratory for the use of the State Agricultural Experiment Station, under the direction of the Board of Managers of the State Agricultural Experiment Station, on land selected by the said Board of Managers; *provided,* such land shall be acquired without cost or expense to the State of New Jersey; which sum the treasurer of this State is hereby authorized to pay for such purpose to the Treasurer of said State Agricultural Experiment Station, upon the warrant of the Comptroller, as bills therefor shall be presented, marked approved by the President and two members of the said Board of Managers of said State Agricultural Experiment Station.

2. *And be it enacted*, That the Chemist or Chemists of the State Agricultural Experiment Station shall analyze all samples of milk, butter or other farm products, or the imitations thereof, that may be sent to said Station by the State Dairy Commissioner and his assistants and agents, and shall report to the said Commissioner the results of such analyses, and the costs thereof shall be paid out of the appropriation made to said Station.

3. *And be it enacted*, That this act shall take effect immediately.

Approved April 23d, 1888.

An Act to prevent the spread of fungous diseases of plants.

WHEREAS, The officers of the State Agricultural Experiment Station have discovered certain new fungous growths that threaten serious injury to important agricultural interests of the State; therefore,

1. BE IT ENACTED *by the Senate and General Assembly of the State of New Jersey*, That when the officers of the State Agricultural Experiment Station shall discover any new fungous growth which is doing injury to plants or vines, and while the same is confined to limited areas, they are hereby authorized and empowered to enter upon any lands bearing vines or plants so affected, and destroy the same by fire or otherwise, as they shall deem best.

2. *And be it enacted*, That any damage to private property resulting from the operation of destroying the said fungous growth by the officers of the State shall be certified to by them, and the amount of damage paid to the owners thereof from the same fund and in the same manner as is paid to owners of diseased animals killed by order of the State Board of Health.

3. *And be it enacted*, That expenditures under this act shall not exceed one thousand dollars in any one year.

4. *And be it enacted*, That this act shall take effect immediately.

Approved May 23d, 1890.

An Act to establish a Weather Service in New Jersey, and to provide for the appointment of a Board of Directors and President thereof, and appropriating money to pay the actual expenses of the same.

1. BE IT ENACTED *by the Senate and General Assembly of the State of New Jersey*, That the establishment of a Weather Service being

necessary to secure a complete history of the weather of New Jersey, in order to furnish trustworthy material for study of its climate, to acquaint the people of the State with the physical conditions of every locality, based upon reliable climatic data, and during the growing season to furnish reliable information as to the actual condition of the staple crops, thereby greatly benefiting the agricultural, commercial and municipal interests, there is hereby created at the Agricultural Experiment Station, New Brunswick, a Central Weather Station.

2. *And be it enacted,* That the Director, the Senior Chemist, the Professor of Botany and Horticulture, and a fourth person, to be appointed by the Governor, shall constitute a Board of Directors, and be duly qualified as like officers of the State.

3. *And be it enacted,* That the Director of the State Experiment Station is hereby appointed President of the Board, who, by and with the advice of the Director, shall establish, if practicable, one volunteer Weather Station in each county of the State, and furnish the same with a set of standard instruments, instrument shelter, rain and snow gauge, and that said Director shall supervise the same; he shall receive reports therefrom and reduce the same to tabular form, and report the same monthly for publication as the New Jersey Weather Report, and shall annually make a report to the Governor, which shall contain a detailed statement of all expenditures made during the year and a summary of the observations taken at the various Stations.

4. *And be it enacted,* That the President of the Board shall print, under contract, copies of each monthly report, and such weekly reports during the growing season as may be deemed advisable, the same to be distributed by the Board.

5. *And be it enacted,* That there is hereby appropriated for the establishment of said Weather Stations the sum of one thousand dollars, or so much thereof as may be necessary for the purpose of meeting the actual expenses of carrying out the provisions of this act; no part of said sum shall be paid for salaries of any officer or for office rent.

6. *And be it enacted,* That no money shall be expended except under the order of the President-Director, by and with the approval of the Board.

7. *And be it enacted,* That this act shall take effect immediately.

Approved June 19th, 1890.

CHAPTER CXVII.

A Further Supplement to an act entitled "An act to provide for the establishment of an Agricultural Experiment Station," approved March tenth, one thousand eight hundred and eighty.

1. Be it enacted *by the Senate and General Assembly of the State of New Jersey,* That the expenses incurred by the Board of Managers of the New Jersey Agricultural Experiment Station—in printing the bulletins issued from said Station, containing analyses of fertilizers, fodders, feeds, soils, and so forth, the results of investigations in feeding animals, in testing the adaptability of soils and manures for the various cereal, fruit and vegetable crops, and such other results of investigations as may be deemed by the Board of Managers to be of immediate usefulness to the citizens of the State—when presented to the Comptroller of the State, accompanied by the proper vouchers, duly certified by the President and Secretary of the Board of Managers, shall, upon warrant of said Comptroller, be paid out of the State Treasury.

2. *And be it enacted,* That such payments shall be in addition to the annual appropriation now made for the payment of the expenses of said Station.

3. *And be it enacted,* That this act shall take effect immediately.

Approved May 1st, 1894.

LAWS OF NEW JERSEY.

An Act to regulate the manufacture and sale of fertilizers.

1. That every commercial fertilizer which shall be offered for sale in this State shall be accompanied by an analysis, stating the percentage therein of ammonia, or its equivalent of nitrogen; of potash, in any form or combination soluble in distilled water, and of phosphoric acid in any form or combination; the portion of phosphoric acid soluble in distilled water; that portion soluble in a neutral solution of citrate of ammonia at a temperature not exceeding one hundred degrees Fahrenheit; and that portion of phosphoric acid not soluble in either of the above-named fluids, shall each be determined separately; and the material from which the phosphoric acid is obtained shall also be stated; a legible statement of such analysis shall accompany all packages or lots of over one hundred pounds, sold, offered or exposed for sale.

2. That the Chemist of the State Board of Agriculture shall be the Inspector of Fertilizers; it shall be his duty to analyze one or more samples of every kind of commercial fertilizers coming within the provisions of this act, which may be offered for sale within the State, and of which he shall be informed.

3. That manufacturers, dealers, and all persons interested, may obtain an analysis by notifying the Chemist of the State Board of Agriculture, upon which notification he shall be authorized to analyze, at his discretion, samples selected by himself, and to furnish certified copies of such analyses to the persons on whose application they were made; and it shall also be his duty to report all such analyses to the State Board of Agriculture.

4. That the Chemist of the State Board of Agriculture shall receive for each certificate of analysis made by him a sum not to exceed fifteen dollars, to be paid by the person or persons applying therefor.

5. That any person selling, offering or exposing for sale any commercial fertilizer without the analysis required by the first section of this act, or with an analysis stating that said fertilizer contains a larger percentage of any one or more of the constituents mentioned in said section than is contained therein, shall forfeit fifty dollars for the first offense and one hundred dollars for each subsequent offense.

Approved March 24th, 1874.

SUPPLEMENT.

Sec. 1. That the penalty or penalties prescribed in section five of that act may be sued for and recovered, in an action of debt, in any court of competent jurisdiction in this State, in the name of any person who will sue for the same, one-half thereof for his own use, and the other half to be paid to the County Superintendent of Public Schools of the county in which such suit or suits shall be brought, for the use of the public schools in their county.

Approved March 31st, 1875.

CHAPTER CXIX.

A Supplement to an act entitled "An act to regulate the manufacture and sale of fertilizers," approved March twenty-fourth, one thousand eight hundred and seventy-four.

1. Be it enacted *by the Senate and General Assembly of the State of New Jersey,* That the fifth section of the act to which this act is a supplement, which section now reads as follows:

" 5. *And be it enacted,* That any person selling, offering or exposing for sale any commercial fertilizer without an analysis required by the first section of this act, or with an analysis stating that said fertilizer contains a larger percentage of any one or more of the constituents mentioned in said section than is contained therein, shall forfeit fifty dollars for the first offense and one hundred dollars for each subsequent offense," be and the same is hereby amended so as to read as follows:

5. *And be it enacted,* That any person selling, offering or exposing for sale any commercial fertilizer without an analysis required by

the first section of this act, or the act to which this act is a supplement, or with an analysis stating that the fertilizer contains a larger percentage of any one or more of the constituents mentioned in said section than is contained therein, shall forfeit fifty dollars for the first offense and one hundred dollars for each subsequent offense; *provided further*, that the provisions of this section, or the act to which this act is a supplement, shall not apply to any manure sold at a price not exceeding one-half a cent per pound, nor to any imported guanos.

2. *And be it enacted*, That this act shall take effect immediately.

Approved March 27th, 1878.

A Supplement to an act entitled "An act to provide for the construction of a State Laboratory for the State Agricultural Experiment Station," approved April twenty-third, one thousand eight hundred and eighty-eight.

1. Be it enacted *by the Senate and General Assembly of the State of New Jersey*, That the further sum of eight thousand and eight hundred dollars be and hereby is appropriated for the purpose of paying the costs and expenses necessarily incurred in the construction and completion of the State Laboratory for the use of the State Agricultural Experiment Station, which sum of eight thousand and eight hundred dollars shall be paid by the Treasurer of the State, upon the warrant of the Comptroller, to the Treasurer of the said New Jersey Agricultural Experiment Station.

2. *And be it enacted*, That this act shall take effect immediately.

Approved April 17th, 1891.

FOURTEENTH ANNUAL REPORT

OF THE

NEW JERSEY STATE

Agricultural Experiment Station

AND THE

SIXTH ANNUAL REPORT

OF THE

New Jersey Agricultural College Experiment Station

FOR THE YEAR

1893.

PART II.

TRENTON, N. J.:
THE JOHN L. MURPHY PUBLISHING COMPANY, PRINTERS.
1894.

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TABLE OF CONTENTS.

VI. REPORT OF THE ENTOMOLOGIST—*Continued.* PAGES.

ORGANIZATION

OF THE

NEW JERSEY AGRICULTURAL COLLEGE EXPERIMENT STATION.

BOARD OF CONTROL.

EXECUTIVE COMMITTEE OF THE BOARD.

OFFICERS OF THE STATION.

AUSTIN SCOTT, Ph.D., LL.D., Director.
Professor JULIUS NELSON, Ph.D., Biologist.
Professor BYRON D. HALSTED, Sc.D., Botanist and Horticulturist.
Professor JOHN B. SMITH, Sc.D., Entomologist.
ELISHA A. JONES, B.S., Superintendent of College Farm.
IRVING S. UPSON, A.M., Disbursing Clerk and Librarian.
CHARLES A. POULSON, Mailing Assistant.
LEONORA E. BURWELL, Clerk to the Director.
AUGUSTA E. MESKE, Stenographer and Typewriter.

FINANCIAL STATEMENT.

THE TRUSTEES OF RUTGERS COLLEGE

FOR

THE NEW JERSEY AGRICULTURAL COLLEGE EXPERIMENT STATION

IN ACCOUNT WITH

THE UNITED STATES APPROPRIATION.

1893.				Dr.
	To receipts from Treasurer of the United States as per appropriation for year ending June 30th, 1893, under act of Congress approved March 2d, 1887			$15,000 00
			Cr.	
June 30.	By	salaries	$6,997 25	
"	"	labor	1,436 11	
"	"	supplies	222 33	
"	"	freight and expressage.	157 20	
"	"	postage and stationery	853 27	
"	"	printing	625 49	
"	"	library	1,071 12	
"	"	tools, implements and machinery		
"	"	scientific instruments		
"	"	chemical apparatus and supplies	386 99	
"	"	furniture	64 00	
"	"	general fittings	1,511 78	
"	"	fencing and drainage		
"	"	live stock	280 57	
"	"	traveling	648 31	
"	"	incidental expenses		
"	"	buildings	745 58	
			$15,000 00	$15,000 00

We, the undersigned duly appointed auditors for the corporation, do hereby certify that we have examined the books and accounts of the Experiment Station of the New Jersey Agricultural College, for the fiscal year ending June 30th, 1893 that we have found the same well kept and correctly classified as above, and that the receipts for the time named are shown to have been $15,000, and the corresponding disbursements $15,000, for all of which proper vouchers are on file, and have been by us examined and found correct—thus leaving no unexpended balance to be accounted for in the fiscal year commencing July 1st, 1893.

AUSTIN SCOTT,
G. C. LUDLOW,
Auditing Committee.

I hereby certify that the foregoing statement or account, to which this is attached, is a true copy from the books of account of the institution named.

FREDERICK FRELINGHUYSEN,
Treasurer Rutgers College.

REPORT OF THE DIRECTOR.

REPORT OF THE DIRECTOR.

AUSTIN SCOTT.

To His Excellency George T. Werts, Governor of the State of New Jersey:

SIR—In compliance with an act of Congress, approved March 2d, 1887, and with an act of the Legislature of this State, approved March 5th, 1888, I beg leave to submit, on behalf of the Trustees of Rutgers College, the sixth annual report of the operations of that department of the College which has been organized in accordance with said act of Congress, and is known as "The State Agricultural College Experiment Station."

The organization and control of the Station were placed, by a resolution of the Trustees of the College, in the hands of an "Executive Committee on the Agricultural College Experiment Station," consisting of the following gentlemen:

The Staff of the Station on June 30th, 1893, was as follows:

AUSTIN SCOTT, Ph.D., LL.D., Director.
JULIUS NELSON, Ph.D., Biologist and Investigator of the food products of the State.
BYRON D. HALSTED, Sc.D., Botanist and Horticulturist.
JOHN B. SMITH, Sc.D., Entomologist.
ELISHA A. JONES, B.S., Superintendent of the College Farm.
IRVING S. UPSON, A.M., Disbursing Clerk and Librarian.
CHARLES A. POULSON, Mailing Assistant.
LEONORA E. BURWELL, Clerk to the Director.

In the annual reports upon the work of the Station, submitted regularly since 1888, in order to make the annual report of the Station work agree, in the time covered, with the annual report of the State Station, details of work, not only up to June 30th, but for the entire year, to December 31st, were submitted. For the same reason, the detailed report of the Station work is made this year to December 31st, 1893.

The following paragraphs summarize the work of the Station during the year:

The report of the Biologist is on the use of Koch's lymph in the diagnosis of tuberculosis of cattle.

The present revival of interest in the question of the relationship of bovine tuberculosis to human tuberculosis has been due to the accumulation of evidence showing, on the one hand, the danger of infection due to the use of the milk of tuberculous cows as food; and on the other, that a test by the hypodermic injection with Koch's lymph is a far more efficient means for diagnosing the presence of this disease in cattle than is physical examination, on which veterinarians have hitherto relied. The Biologist has applied this test to the entire College herd of more than forty animals, and all the animals that have shown "reaction" have been slaughtered, carefully examined and buried. Twenty-seven animals have been thus subjected to autopsy, and unmistakable tuberculous lesions, often in an advanced stage, were discovered in all except two animals, although only twelve of them were pronounced "suspected" from the physical symptoms. The two exceptions, however, may not prove to be really such, as evidence of disease was present, and the microscopical examination is not yet completed. The milk of these animals was prepared for examination, as well as specimens of tissues of various organs. Several fœtuses were preserved, the examination of which will throw some light on the liability to congenital transmission of the disease. The study of this material is now in progress in the biological laboratory. The report of the Biologist herewith presented aims mainly at the solution of the question of what constitutes a "tuberculous reaction," and a revision of former practice in this regard is made in the direction of greater accuracy.

In the Botanical Department the work has been largely along lines previously pursued, namely, with weeds and various fungous troubles of farm, garden and greenhouse plants.

A collection of weeds was prepared and displayed at the World's Columbian Exposition, in the Alcove on Botany in the Department of Experiment Stations. A second collection (two hundred species), not a duplicate of the above, by a separate request, was shown in the Department of College Work of the Agricultural Colleges. Likewise a set of weed seeds of one hundred kinds was exhibited at Chicago. In connection with this work a check-list of the weeds of North America, containing eight hundred and eighteen numbers, has been revised for publication in this report. An outline of an illustrated lecture upon weeds, prepared for the Exposition, is also given.

The study of the root system of weeds has been continued and attention paid to some fungous enemies of the weeds, particularly a destructive rust in the Canada thistle.

A peculiar abnormal and injurious growth in sprouting potatoes has been studied.

In connection with the studies of leaf blights a process of sun-printing has been developed that gives excellent results and saves much time in recording the appearances of fungous depredations to the foliage.

The diseases of the strawberry have been considered, and a new fungous enemy is found that is quite injurious to the foliage. "Club-root of Cabbage and its Allies" is the title of a fully-illustrated bulletin (No. 98) issued from the Station in December.

Under truck crops investigations have been made with cucumbers, melons and beans to show the identity of one of the leading fungous diseases of these plants. A study of the causes for peas failing to germinate has shown that at least three fungous enemies are present in the seed and young seedlings. A fatal blight to egg-plant and tomatoes in Florida has been tested here in the field without injurious results.

Field and laboratory studies have been continued upon garden fruits, chiefly apples, during the year.

Several kinds of troubles complained of by florists have received attention. Some of these come from the ornamental grounds but chiefly from the greenhouses. Thus a study of carnation, rose, cyclamen, calla, palm, orchid and fern diseases has been continued.

The work in the Department of Insects has been, in the main, along the same lines as in previous years.

Further studies were made on the sweet potato flea-beetles and on the melon lice, in continuation of work begun in previous seasons.

The sudden appearance, in destructive numbers, of the onion-maggot in Cumberland county demanded attention early in the summer, and some remarkably successful experiments were made.

A series of careful laboratory experiments was made with various fertilizers to determine their effect upon the larva of the pear-midge, and these were supplemented by a field experiment on a large scale, and both experiments were completely successful, and, confirming each other, at last gives us control of this most serious of dangers to pear-growing.

This subject of the effect of fertilizers upon insects has continued to form one of the main lines of experiments, together with a study of the effects of methods of cultivation in favoring or checking insect increase. It is believed that farming can be carried on so as to render it impossible for many of the species that are most injurious at present to continue to breed in cultivated lands.

As is usual, a number of unexpected insect outbreaks occurred, and the facts of each were studied and will be found reported upon.

A number of species injurious elsewhere have been gradually making their way into our State and are under observation, among them the strawberry weevil, the pear psylla and a new asparagus beetle.

The collection of material for the economic series has been continued, and there are now practically illustrated in proper boxes a very large proportion of the injurious insects of our State.

A considerable aid in this branch was rendered by a small appropriation from the World's Fair Commission, with which ten boxes were prepared for exhibition at Chicago, and which now form part of the museum exhibit.

The use of photography in fixing the appearance of insects and plant diseases has been much extended, and a valuable outfit has been gradually obtained. Many dozens of negatives, illustrating insects and their work, and plants, fruits and seeds in health and disease, have been made. The duties of Station Photographer have gradually devolved upon the Entomologist, and the results of the work done are utilized in the reports and bulletins of the Station.

The "statement of receipts and expenditures," herewith submitted, covers the fiscal year provided for by the United States law—from July 1st, 1892, to June 30th, 1893.

REPORT OF THE BIOLOGIST.

REPORT OF THE BIOLOGIST,

ON THE USE OF KOCH'S LYMPH IN THE DIAGNOSIS OF TUBERCULOSIS IN CATTLE.

§ 1. *Brief Record of Operations at the College Farm.*

Early in June, 1893, I was asked to examine, with the microscope, the milk of a Holstein cow, Tryntje von Hollingen by name, a member of the College farm herd. This cow had been suspected of being tuberculous, although at this time she was in fair condition, coughed only occasionally, but was somewhat languid and the right hind quarter of her udder presented the symptoms of garget—being hard and swollen.

A thorough and extended microscopical study of her milk by numerous methods failed to give me any evidence of the presence of the germ of tuberculosis. The milk was of excellent quality.

Finally it was decided to test her by the Koch test, which consists in the hypodermic injection of a 10 per cent. solution of Koch's lymph (or tuberculin) in a 1 per cent. solution of carbolic acid. Experience had abundantly proven to previous observers that if this is done on a healthy cow no change of her temperature results, but if she have tuberculosis in the slightest degree there is a fever reaction, the temperature rises in from six to twelve hours after injection and remains up for a number of hours before falling back again to the normal.

It is well known to veterinarians that the normal temperature of a cow in the early morning is lowest, so that if the injection be made in the evening the reaction, if any, will occur when the temperature should be lower than the initial temperature observed in the experiment. When it is found that the morning temperature, after inoculation with tuberculin in the evening, is higher than the evening temperature, a reaction is at once predicated and this reaction is all the more certain in proportion to the absolute rise. So certain is it that a cow

which shows a reaction is tuberculous that the State would risk little if any money, should it promise to pay for every cow showing reaction which on being killed failed to show the presence of tuberculosis.

Accordingly, on the evening of July 24th Tryntje was injected with 80 minims of tuberculin solution—a large dose, determined by the large size of the cow. The temperature record observed was as follows:

8:00 p. m.	10:00 p. m.	12:30 a. m.	3:00 a. m.	5:00 a. m.	7:15 a. m.	10:00 a. m.	11:30 a. m.
103 35° F.	103.1	103.2	102.2	102.2	101.2	101.5	102

It is plain that the above record is not a reaction, and I so reported; but in the light of subsequent experiments, it now seems possible that a reaction took place.

August 11th. A cow from the farm, on being slaughtered, showed abscesses in lungs and near kidneys, which, on microscopic examination, showed the presence of the germs of tuberculosis. At this date the milk from the gargety quarter of Tryntje's udder suddenly changed for the worse; it became watery, coagulated and had little fat or cream content. Microscopic examination showed it to be full of decomposing cells and various bacteria, among which the tubercle germ was found to be present. The cow was then isolated from the other members of the herd, and a continued observation made of her milk, which was thrown away so far as it was not used in experiments.

October 29th a normal, apparently healthy, calf was born to Tryntje. This was isolated and fed by milk from the three teats which produced milk of good quality. The cow had been dry for several weeks before calving. The right hind teat continued to give a small amount of abnormal milk. November 9th the calf was killed and specimens taken of its different organs for microscopic examination and the rest of the carcass was buried, although to the eye it presented a wholesome appearance. At this time it was noticed that the milk of the right front quarter of Tryntje's udder was also becoming abnormal. Experiments were continued, and I was greatly interested in studying certain physico-chemical reactions which I supposed might possibly be used in determining whether the milk of a cow is affected by tubercle bacilli or not, when the news came November 30th, that Tryntje was dead.

The autopsy was held that afternoon, in a field distant from th

barn, and it showed clearly that death was the result of tuberculosis. The muscles seemed to be the only tissues not yet converted into tuberculous masses, so extreme was the invasion of this mysterious and irresistible disease. After the birth of the calf, the failure of health of the mother was rapid; the change during the last week was so great that whereas a few days before, the cow seemed likely to live for many months, after death (I meanwhile had not seen her) she presented an appearance of emaciation which, had I seen before, would have determined her immediate slaughter.

Meanwhile, the farm management had called in Dr. E. L. Loblein, veterinary surgeon, to examine the herd. Two cows presented unmistakable signs of tuberculosis, and it was determined to test Koch's lymph again. November 8th, Tryntje's calf was injected with 20 minims tuberculin, and Maria Starr, a Holstein, received 50 minims, the temperature record being as follows for the calf:

6:00 p. m.	8:45 p. m.	2:00 a. m.	5:00 a. m.	7:15 a. m.	12:00 m.	4:00 p. m.
102.6 (before injection).	102.8	103.2	103.2	104	104.8	103.6
102 (immediately after).						

This appeared like a reaction, although the normal temperature of young calves is much higher than of cows, and is readily disturbed, so there is some doubt. The record for the cow was:

6:30 p. m.	8:55 p. m.	2:15 a. m.	5:00 a. m.	7:30 a. m.	12:00 m.	4:00 p. m.
102.5 (before).	103.4	106.3	106.3	105.8	103	103.3
102.6 (after).						

This is a decided reaction.

A week later, the other cow, Marion Perkins, a native, was injected with 40 minims and gave this record:

5:00 p. m.	8:00 p. m.	2:00 a. m.	5:00 a. m.	8:00 a. m.	12:00 m.	3:30 p. m.	6:00 p. m.	8:00 p. m.
102.4	103.4	105	104.4	105.8	106	105	105.8	105.6

Next morning at 6 A. M., 101.8, or more than two and a half degrees (2.5°) lower than on the previous morning, when the tuberculin was acting; hence, an evident reaction. After the death of Tryntje, the slaughter of these two cows, which had been isolated as soon as the reaction was shown, was decided upon, but the desire to continue certain researches upon the milk of Maria Starr delayed the execution.

Her milk was fed to a calf born to Fillpail November 8th (the mother at that time not suspected, but later proved to be tuberculous). This calf was injected with 15 minims lymph December 11th, and gave this record:

5:30 p. m.	9:00 p. m.	2:00 a. m.	5:00 a. m.	9:00 a. m.	12:00 m.	4:00 p. m.	8:15 p. m.	10:00 a. m.
103	101.8	104.2	104.6	104	104.5	103 6	104	103.6

While this appeared to be a reaction, the fact of the youth of the creature caused a doubt to remain. Accordingly, on the night of December 15th, Mr. E. A. Jones, the College Farm Superintendent, who had taken the above record, observed, at my request, the temperature of the calf when it was not under the influence of tuberculin, with the following results:

6:00 p. m.	10:00 p. m.	2:00 a. m.	5:30 a. m.
101.8	102	101.6	101.8

A comparison with the corresponding hours of December 11th, after injection, shows an evident reaction. This calf was butchered January 15th; it was in prime condition, without a flaw to the eye, nevertheless specimens of various organs were taken and prepared for microscopic examination. December 23d, the two cows whose records we have presented, were killed and autopsied near the grave of Tryntje, with the following results:

In the case of Maria Starr (66), the membrane lining the chest walls was studded with tubercles (pearl disease), the bronchial glands were enlarged with tubercles, the lungs were filled with large cheesy bunches, the liver was covered with similar tubercles, and the caul, mesenteries, and intestines showed small scattered tubercles or pimples, known as miliary tubercles.

In the case of Marion Perkins (73), the left lung was nearly solid and the right partly invaded by tubercles; the bronchial and mediastinal glands were enlarged and converted into a bright-yellow cheesy material. She was evidently not so tuberculous as the former case but leaving Tryntje out of comparison, would be still considered as in an advanced stage of tuberculosis.

The results of these autopsies determined the farm management on a thorough inspection of the herd. Dr. Loblein examined the herd keeping his results to himself temporarily, and I injected the herd with tuberculin, Mr. Jones taking the temperatures. Sufficient tuber-

ılin (thirty dollars' worth, or 240 minims, equals 15 cubic centime-rs) was secured, and on the 29th day of December, nineteen cows, ıd January 2d, sixteen others were injected, the records of which ill be found in the tables accompanying this report. Two heifers ıd a bull were left uninjected, the lymph having been exhausted. he bull was killed without injection, but found to be healthy. The vo heifers were injected by Dr. Loblein at a later date. (See Tables os. 7–43.)

The general results may be summarized as follows: Nine cows are pparently sound, four are doubtfully sound; two are doubtfully ıberculous, six are probably tuberculous, while eighteen may be fely killed as tuberculous.

The veterinarian's inspection showed fifteen cows as "suspicious" ıses, varying from "very suspicious" to "slightly suspicious." hen these suspicious cases were compared with the classification ıder the Koch test it was found that two cases came under the apparently sound" group, one under the "doubtfully tuberculous" oup, two under the "probably tuberculous" group and eight under e "certainly tuberculous" group. The other eight tuberculous ıimals were pronounced O. K.

The cows were killed in the order of their certainty of reaction, ıd every member of the certainly-tuberculous and probably-tubercu-us groups was seen to be decidedly tuberculous, except two cases in e "probable" class, about which there is doubt until the micro-opic evidence is in.

Thus there has been a thorough weeding out of the tuberculous ttle, which, but for the use of the Koch test, would have been im-ssible. Every new cow now added to the herd is first tested by jection, and she is purchased only when her temperature record is ıaffected by the injection. The evidences that such cows are sound e discussed in a later section of this report.

The stables and quarters which the College herd has used have en thoroughly cleaned and disinfected, and the Koch test will be ed from time to time in the future to detect any case of tuberculosis ising in the herd in its incipiency. In this way the herd can be pt clean and reliable. The reason for all this care and expense ll appear evident to one who considers the points presented in the xt section.

TABULATION OF RESULTS OF DIAGNOSIS BY KOCH TEST COMPARED WITH DIAGNOSIS BY PHYSICAL EXAMINATION.

Diagnosis by Koch's Lymph.		Of which, respectively,	Were declared "suspicious" from the physical examination.
Certainly tuberculous	18		10
Probably "	6		2
Doubtfully "	2		1
" sound	2		
Probably "	2		1
Evidently "	9		1

§ 2. *What is Known about Tuberculosis.*

Tuberculosis, also known as phthisis, pearl disease or consumption, has hitherto remained incurable; it is the most widely spread scourge that mankind has to deal with. The proportion of adult deaths due to this cause has been placed at a third, while at least a fifth of the infant mortality has been traced to this cause. Some authorities say that about a seventh of the whole population is carried off prematurely by this disease. There are many persons who die of other diseases, and again many whose bodies are not examined, who in all likelihood have developed tubercles to an unknown extent. Then, too, there are other diseases, evidently closely related, but in just what way science has not yet discovered, such as scrofula and lupus; even syphilis and leprosy have been suspected of having relationship here. With all due reserve, the most conservative of physicians admit the prime importance of studies relating to this prince of maladies.

In 1882 Robert Koch definitely settled the question of the cause of tuberculosis by discovering the parasite, the presence of which in the animal tissues causes those degenerations and growths of abnormal tissue known as tubercles. This parasite is a bacterium or *bacillus*, a rod-like living organism less than one seventy-thousandth of an inch thick and averaging one eight-thousandth of an inch in length. Like other bacteria it grows and multiplies by feeding on the juices of the body and reproduces by continual breaking into halves, each of which is a complete organism from its birth. We can easily calculate the immense numbers that would exist in a short time if the conditions for feeding and reproduction continued favorable. Fortunately our tissues fight these parasites and it is probable that the tuberculous mass results from an attempt on the part of the tissue to imprison

these marauders, because the blood-supply is cut off from the gland or locality of growth by the formation of fibrous material, so that the internal parts of the tubercle gradually change into cheesy material or undergo other degenerative changes the nature of which is obscure.

Since this discovery by Koch, physicians have separated into three divisions on the question of the cause and nature of consumption.

The first class says, let the germ once invade a healthy man and he will contract the disease; hence the full cause of the disease is the presence of germs; therefore we must combat them, kill them, isolate all consumptive persons and animals, destroy all tuberculous meat and food products; in short, as soon and as thoroughly as possible, eradicate this germ. This group of physicians is giving way, in part, to a second group, now largely increasing in numbers, who believe that an appropriate soil is necessary, a weak condition of constitution, produced by poor feeding, bad habits and especially by poor ventilation. Such a constitution presents appropriate conditions for the invasion of disease germs. Science has considerable to say on this point just now, and it seems likely that the "proper soil" theory will narrow down to this, viz., *the body is too weak to combat the entrance of germs or to restrict them after entrance.* This is done in various ways, the most usual being the eating (to use a popular expression) of the germs by the white cells of the blood, the lymph corpuscles; also the secretion of special poisons by certain tissues, inimical to the germs, which are thus met by their own weapons, for it is now recognized that bacteria produce disease by means of the poisons they excrete while trying to gain their own subsistence. Scientific investigation will doubtless discover other methods the body has of fighting against these germs, the sum total of which powers constitutes *good health.*

The third group of theorists is loth to give up the old view of disease, that it is a condition of constitution produced by failure of life forces to keep up a certain "vital force" in face of external changes. Thus it follows that the environment causes disease in the weak, *e. g.* a cold is produced by exposure. The products of disease, mucous or tubercle or what not, become breeding-grounds for the bacteria which may or may not find their way thither. Certain cases of tubercle, in which investigators failed to find the germs, are brought up in evidence, and the reply of their opponents that the

bacilli must have been present originally is ridiculed as begging the question.

It seems apparent that the members of the second group hold all that is valuable in the evidence supporting the first and third classes of views, and those who are familiar with disease germs by actual experiment with them belong overwhelmingly to the middle class. Thus the present verdict of authority emphasizes hygienic as well as germicidal and quarantinal methods.

Are all tubercular growths due to a single species of germ? From what we know by analogy of germ investigations in general, we might expect that the varieties of tubercle and of consumption are due entirely to individual peculiarities of the person reacting on one species of germ. Thus, the germ of quick consumption, when transplanted into another person, need not produce this variety of disease, and similarly, the germ of chronic tubercle, in all likelihood, does not change its nature when transplanted into a person who, as a result, suffers from quick consumption. It is rational to believe that when a person who has suffered for years from the "slow" variety suddenly develops the "quick" variety, that his constitution has finally given up the struggle. We all give up the struggle of life sooner or later, and these germs are only a specific form of the varied forces that cause death universally. The burden of proof lies with those who assert that there are various distinct species of consumption germs. Some tubercles, which are produced apparently without the agency of germs, may be due either to ultra-microscopic spores, or the germs may have disintegrated, possibly forming spores, which we know are difficult, if not practically impossible, to demonstrate in certain cases.

The germ of tuberculosis in animals differs slightly as to size from that thrown up in the sputum of consumptives, yet the characteristic forms of tuberculosis have repeatedly been produced in animals inoculated with tuberculous germs taken from man and from other species of animals at will. Science has, indeed, shown that other germs, as in actinomycosis, for example, do produce forms of tubercle that have been mistaken for tuberculosis, but the same science that demonstrates this specific difference is competent, by means of similar methods, to pronounce upon the question of the unity of the disease tuberculosis. While we admit that the question is not finally closed, we must act on the evidence already in, and that evidence is in favor of such unity.

To what extent are our domestic cattle affected with tuberculosis? :atistics of slaughter-house and meat inspection in various countries ıd cities give as an average about 3 per cent., but locally the ɪrcentage may rise far higher or may be lower; 16 per cent. and 26 ɪr cent. are some of the figures quoted. One authority has stated ıat 50 per cent. of the cattle of Holland was infected. The entire ollege herd of fifty-seven animals of the Maine State Agricultural ollege was slaughtered and buried as the result of physical examinaon alone. Our herd has been found tuberculous to the extent of) per cent. A herd at Burlington, N. J., injected with tuberculin st autumn, was found affected to the extent of 60 per cent. A herd high-bred Jerseys at Villa Nova, Pa., was tuberculous to the :tent of 50 per cent. The Willard Asylum, N. Y., lost nearly two ındred high-bred Holsteins. And, as inspection goes on, cases of milar great infection are continually being reported. When once berculosis has gained foothold in a herd, it rapidly spreads through e entire lot. Our statistics show that by the use of tuberculin ice as many cows were discovered infected as physical examination one would have revealed. Statistics gathered in the past, based on ıysical examination alone, are undoubtedly too small. Even those ısed on meat inspection are probably under the truth. The majority the cows shown to be tuberculous by our use of the Koch test had berculosis in either incipient degree or so slightly that very thorough :amination of entrails and the lymphatic structures connected with e lungs became needful in order to diagnose the disease from topsy. Are we sure that such examination of structures, usually rown on the refuse pile, though sometimes used in the manufacre of sausages, was absolutely thorough? As regards the carcass, immed of these organs, it has been shown that only in the severest ses, and then only to the extent of 10 per cent., is the muscular ɪrtion invaded by bacilli, and then only to microscopic extent, quiring inoculation experiments to demonstrate. Most observers ve failed utterly to find the bacilli in the meat of tuberculous imals after the most careful work, consisting of inoculation periments.

How far are other animals affected? The domestic fowl is even ɔre subject to tuberculosis than the cow. Zürn found sixty-two ses in six hundred examinations. More than ten per cent. Cats, gs and especially swine are susceptible to this contagion, as are, in a

greater degree, captive animals. Rabbits, guinea pigs and mice ar so very susceptible that they are used in all delicate inoculation ex periments to test the presence of bacilli.

This disease has been termed both contagious and infectious, bu both these terms grow out of the fact that it is due to a germ, an thus the old distinction between these terms is seen to be of secondary perhaps trivial, value. Certain it is that no matter how susceptibl a person or animal may be, if the germs are not introduced into th system no disease of this sort will result. It is this conviction, rest ing on sure foundations, that is the real animus in the work c physicians as they agitate in favor of methods for stamping out c restricting the disease, on the one hand, by a quarantine of con sumptives, with extreme care in dealing with sputa; and on th other, by the destruction of tuberculous animals and care in the dis posal of their carcasses.

What conditions favor the state of susceptibility to consumption First and foremost is bad ventilation. Naturally this weakens th life-forces, and at the same time presents the germs in increased num bers in every breath. While in cultures, and in very susceptib bodies, a single germ can generate millions of offspring, it is foun that the question of numbers of these parasites counts for mucl There is plenty of evidence to show that tuberculous subjects, wheth human or animal, are almost exclusively or at least in great majori produced in ill-ventilated habitations. Next, if not of equal impor ance, is sunlight. I find this point not sufficiently emphasized in tl numerous reports and hygienic recommendations that have been se out. People, as a rule, are afraid of the light. This is one of tl most sinful of unhygienic practices. The shady side of streets receiv more visits annually from the physicians than do the sunny side, spite of numerous sun shutting-out devices. Koch states that a fe hours of sunlight acting on a tuberculous germ will destroy it, and few days of diffused daylight are germicidal. Why neglect this chi of disinfectants? We have bacteria classified as aërobic and anaërob according as they thrive with or without access of air. We need classify bacteria as photic and aphotic. A next fertile source of su ceptibility is heredity. I find this word used hardly a single time, l writers, in its proper sense. The transmission of a germ from a moth to a fœtus is congenital transmission of disease (or congenital *infectio* and never is itself true heredity, which word means the sum total

the species characteristics as modified by the special environment in which the individual is produced and to which the individuality is due. Thus, if the tissues, by heredity, are strong, the tendency to contract consumption at any period of life, prenatally or postnatally, is slight. But if they are weak, the susceptibility in this regard is strong or certain. This explains why consumption runs in families. Possibly in these cases, many times, the fœtus is infected from a consumptive mother during gestation, or even from a father, before conception, but such transmission is simply early infection. The acquiring of consumption by infection in later life is as truly due to hereditary influence as is fœtal infection, in such cases. In this sense all cases of consumption are always both hereditary and due to infection; but the special sort of infection termed "hereditary" should always be designated as "congenital" infection or transmission.

Finally, we have to enumerate general unsanitary living, overwork, bad feeding, lack of exercise, dissipation and all bad habits that tend to weaken the organism. It has been stated that a healthy lung cannot be infected with tubercle germs, but there must exist some abrasion or lesion, an inflammation, perhaps, due to the irritation of dust particles. Statistics show that workers in an atmosphere filled with dust of various sorts suffer proportionally more from consumption. Such abrasions and inflammations are less apt to arise in one who takes good care of his health, original hereditary endowment being equal. But we all have our special weaknesses, and at those points the fortress is taken by some germ species or other. The weakest are first weeded out. It is our duty to fight disease germs by scientific methods, as well as by our phagocytes and toxalbumins; thus our energies are available in other lines and last longer. But it must never be forgotten that our present immunity from many of the germs about us, at least for the average lifetime of man, has been purchased at the expense of the weeding out of susceptible ancestors, so that we who remain are the descendants of the strongest.

I point out a danger that may arise could we really succeed in extinguishing this species (which is not probable), viz., the evolution of a weakened race, into which, at some future time, some germ now restricted in its operations, shall suddenly make an incursion as a "scourge of God." We, in fact, aid the beneficent work begun by these bacteria when we hasten the death of the animals which we are responsible for having produced, with their weak constitutions: a

weakness due to our forcing methods of feeding, with brewers' grains, for example, our overcrowding and, above all, our close inbreeding. Biology teaches us that the great use of crossing is to produce vigor, but in the evolution of our dairy breeds this is, to a large extent, neglected.

We should always emphasize the importance of hygienic methods of life without lessening that fear of the germs which leads to cleanliness. The promotion of aseptic and antiseptic conditions is only a particular branch of hygiene. In what ways do the germs enter the body—human and animal? Some cases are undoubtedly due to congenital infection or transmission. A case has been clearly established in which a fœtus was tuberculous, while the mother had tubercle in the lung only. It is presumed that at some period a few bacilli or spores had been carried by the blood to the placenta and had been transferred to the fœtal circulation. Possibly, certain leucocytes had been the carriers of the germs, for they, by diapedesis, it seems to me, could be the only agents in such a transfer, as these bacilli are not known to possess locomotor powers. That bacilli multiplying in one part of the body may be transferred to distant portions of the body is evident from an inspection of the evidence presented by numerous histories of cases. It is also shown by the experiment of a Greek physician, who inoculated a man in the thigh, and in a few weeks the lungs, hitherto sound, were thoroughly infected. It is a plausible supposition that the intrasomatic distribution of the bacilli is due to the lymphatic circulation, although we have no evidence as yet that the blood does not also aid. Tuberculosis is primarily a lymphatic disease: the lymph glands are the first to show signs of its presence. We must also remember that the serum currents flow from the blood vessels into the lymphatics.

A second method of infection is through abrasions or wounds of the skin and mucous membranes. Of this several cases are recorded. A third method is through the breathing of air containing the bacilli. In some way due to a lack of proper vigor of the cells lining the bronchial tubes the bacilli are not carried out, but lie and probably breed on the surface before penetrating into the interior. It seems to have been taken for granted that every case of lung consumption has arisen in some way similar to this. But it may be that the lung is frequently infected through intrasomatic distribution. A fourth point of entrance is through the walls of the alimentary canal. The pres-

ence of miliary tubercles on the intestine is supposed to point to this conclusion. But we must not forget that intrasomatic distribution may have followed a primary lesion in the lungs which may have gone no further than a localized abrasion or inflammation of the air-passages. If infection through the food be granted, we must assume that the gastric and intestinal juices have failed to destroy the germ. Then we have still to get it through the mucous membrane, and in this instance the possibility of leucocytal infection and diapedesis must likewise be granted. It is plain that the inference of the method of infection from location of tubercular lesions is a complex one. That infection may be produced both by inspiration and by ingestion, has however, been abundantly proven by experiment.

Next as to the method of intersomatic transmission. We know that in the human subject the expectorations are the prime source of contagion. "Millions of bacilli" have been estimated as the daily output from a single patient. The sputum, dried and turned to dust, is in fit condition to contaminate both air and food. The atmosphere in a room occupied by a small-pox patient is no more filled with disease germs than that occupied by a consumptive. But, of course, we have to take many modifying circumstances into account when we calculate the relative amount of "risk" of contagion or infection in the two cases. These circumstances have been discussed in the preceding pages; they are: light, air, cleanliness, vigor, heredity, closeness of contact, length of exposure and many others. Instances of infection introduced by accessions of consumptives to healthy schools could be cited.

A number of cases are on record of pet animals catching consumption from their masters and mistresses. Even hens fed by a consumptive have become infected. On the other hand, what risk is there of transmission from animals to one another and to man? They do not, as a rule, expectorate, still it has been frequently noticed that the introduction of a tuberculous animal in a herd has been followed by the gradual spread of the disease throughout the herd, beginning with the cows nearest to the source of contagion. In such cases it is said that the drinking vessels receive the germs. This presupposes that there is a gradual working up of small quantities of mucus containing the bacilli. The excrement has been examined and is generally free from these bacilli. It has been suggested that the expiratory

breaths carry out the tuberculous germs, but we certainly need more careful study of these points.

Finally, we have to ask, Does the milk of a tuberculous animal contain tubercle bacilli? This is important because milk is universally used, and is generally taken uncooked. Cooking destroys its digestibility; four per cent. of the fat of raw milk fails to be assimilated; this rises to six per cent. in the case of boiled milk. The non-assimilable nitrogenous ingredients are similarly raised from seven to eight per cent., and the milk-sugar also undergoes a change. These changes do not take place if the milk be heated for a moment up to 185° F., a temperature which is germicidal, provided the milk be not allowed to cool too rapidly.

The high percentage of infants showing intestinal tuberculosis has been thought due to the use of contaminated milk. Older persons using the same milk may not become infected. Other things being equal, the number of germs per volume of milk is very important. The subject has been investigated by feeding experiments, by culture experiments, by inoculation of susceptible animals and by microscopic examination. It was for some time believed, on the statement of Koch, that the milk of a tuberculous cow would not contain tubercle bacilli until the udder tissue became the seat of a tuberculous process. But plainly the bacilli must be transferred thither before the udder can become diseased. In the early stages of tuberculosis very few, if any, bacilli are carried to the udder; but in more advanced cases, showing tuberculosis by physical examination, Ernst and Peters have found bacilli in the milk of one-half of the cases (the udders apparently healthy), although other observers have secured less striking, or more often negative, results. Even with inoculation it is found that if milk which is tuberculous be diluted to a considerable extent, forty or fifty to one hundred parts water being added (or less if milk be added), it loses its infectious properties. Mixed milk is therefore safer than the milk from a doubtful cow, provided only one or two cows in a herd are affected.

Feeding experiments with calves and pigs have given positive results with Ernst and Peters and others, and less positive or negative results with still other observers. Microscopical examination, especially of milk, is the least satisfactory of all methods, because the germs must be sufficiently numerous to give at least one germ for each drop of milk, otherwise the chance of finding the germ is so small as to

crease the tediousness of search beyond practical limits. Ernst and eters, however, were successful in demonstrating the presence of the erms in one-fourth of the cases.

In the light of these experiments *the milk of a tuberculous cow must regarded with suspicion until proven pure.* It is probably easier to erilize the milk than to have it examined. It is certainly risky to se it for feeding animals without boiling. It may, however, be ifely used as a whitewash on the outside of buildings, as when prop-ly salted it makes a valuable paint. The germs have been found qually in the cream and in the milk, so that we are as open to infection rough our butter as through our milk. It is the belief of some physi-ans that if all tuberculous cows were destroyed consumption would isappear from the human family. This is based on the observation aat where cows are absent there is no consumption. By the use of Koch's lymph we are now able to detect twice as many tuberculous attle as was possible by former methods. Should it prove infallible, acceeding in demonstrating *every* tuberculous animal (when used in onnection with physical examination), we have the means wherewith test the truth of the belief that human consumption is derived from ovine tuberculosis. Nothing but good can be the ultimate result rom an attempt to weed out the tuberculous stock in our dairies, and oubtless the breeder and the dairyman will find it to their highest nterest to effect this result as promptly as necessary.

§ 3. *Detailed Record of Operations Relative to the Diagnosis of Bovine Tuberculosis.*

This section supplements section 1, and presents the scientific data f the experiments and observations which are to be discussed in ection 4.

The following order of work was followed as nearly as possible, in he case of each cow in the herd:

(1) Physical examination by a veterinarian.

(2) Temperature *per vaginam* by means of a self-registering clinical hermometer.

(3) Washing (with warm water and soap) of the right shoulder nd rinsing.

(4) Washing with a 4 per cent. solution of creoline, an antiseptic laimed to be superior to carbolic acid.

(5) Injection, hypodermically, of approximately 50 minims (=3 cc. of a 10 per cent. solution of *tuberculinum Kochii* in a 1 per cent. solu tion of carbolic acid—the puncture swabbed with creoline solution.

(6) Temperature tested approximately every three hours for a period of twenty-four hours.

(7) Examination of the records made by each cow and ascertain ment of the amount of reaction, as measured by the highest record compared with the highest normal record. The latter, presumed to be about at evening time, was given by the first two readings taken before the tuberculin had time to act. In some cases a curve of the temperatures was plotted, and in doubtful cases the temperatures were observed again when the animal was not under the influence of the "lymph."

(8) The assignment of each animal to a certain rank, determined by the extent and certitude of the reaction; the order of rank from highest to lowest being taken as determining the order of slaughter We also determined, in case any doubt remained as to the stopping point, that the occurrence of two successive cases of tuberculous-free autopsies be the signal for stoppage.

(9) Samples of milk were drawn into clean tubes stopped with cot ton, the milk being taken from each teat separately.

(10) A portion of the milk was prepared by Thörner's method for determining the presence of tubercle bacilli by microscopic examina tion, after the use of the centrifugal machine. This method consist in first alkalinizing the sample in a test tube with potash to the extent of 1 per cent., next heating until the milk turns brownish and the fat is partly saponified and the casein rendered soluble in acids, then adding an equal amount of glacial acetic acid and heating until a tolerably clear liquid results. This liquid is then whirled with four thousand revolutions per minute, the sediment, containing tubercle germs in a concentrated or aggregated mass, is washed in hot water which is again whirled for ten or fifteen minutes, and the new sedi ment is prepared for microscopic examination. The object is, first, to get rid of the fat globules which always rise in a centrifugal machine and drag at least half the bacteria with them; second, to gather the germs from a relatively large quantity of milk into a small compass so as to insure their being found under microscopic examination Our centrifugal machine was a Babcock tester, run by hand-power capable of giving only one thousand revolutions per minute, and after

thoroughly testing its ability to separate bacteria, and discovering that even after an hour's whirling no appreciable diminution of germs resulted near the surface, while only the coarser sediment (which, however, dragged down a few bacteria) gathered at the bottom of the tubes, I dropped this link in the series of tests.

(11) A portion of the milk was evaporated on glass slips and slides in an incubator at 104° F., and some at 70°. All samples thus prepared were inclosed, when dry, in envelopes and stored for future work.

(12) A final portion of the milk was preserved, either by addition of corrosive sublimate or of bichromate of potash, and stored in cotton-plugged tubes for examination.

(13) The animals were next led to execution, killed, skinned and opened by a butcher, under guidance of the observer.

(14) Samples from each quarter of the udder were preserved in a weak alcohol, saturated with corrosive sublimate. To each piece of tissue was pinned a number, and a record was kept of the reference of each number to the proper kind, location, etc., of specimen. The udder was, in each case, split down into the middle of each side to note if any lesions were present. The inguinal glands were also examined. Specimens of tissues other than udder were usually not taken, except they presented either doubtful features, or something peculiar, or possessed typical value.

(15) The trachea, heart, lungs and mediastinal glands were next removed and thoroughly examined. Note was made of the extent to which these structures were tuberculized, and often samples were preserved for microscopic examination.

(16) The liver and intestines and other abdominal organs were next inspected. If tuberculosis was evident in the thorax, as our object was primarily to test the diagnostic value of the lymph and to destroy the diseased animals, we allowed only a superficial examination of the abdominal viscera to pass. We learned, however, soon to look for lesions in certain favored localities, and these were quickly inspected. These regions usually furnished the largest number of specimens preserved for microtomic work.

(17) The uterus was examined, and if any fœtuses were present, if of small size, they were preserved, and if too large for the museum jars, samples of their organs were taken. In the later cases, but, I regret to say, not in the earlier ones, the ovaries were examined and samples preserved.

We have, therefore, material for study which will throw light on the following points:

(*a*) What tuberculous lesions can be diagnosed by physical examination, and what cannot?

(*b*) What peculiarities characterize a tuberculous reaction with Koch's lymph—that is, can we certainly, by this test, select all tuberculous cattle?

(*bb*) What may be expected as the normal range of temperature of a cow?

(*c*) To what extent is the milk or udder involved in cases of bovine tuberculosis?

(*d*) To what extent is congenital transmission or "fœtal infection" operative?

(*dd*) Does the feeding of milk from tuberculous cattle to calves produce infection?

On all these points we have already more or less evidence, but not so much but that we require more light before any consensus of opinion and legal activity will result. While the primary object has been the removal of tuberculous animals from the College herd, the work has been so done as to enable us to increase our knowledge of this disease, and it is expected that the publication of these results will serve to increase any efforts now made in augmenting scientific knowledge by others who are engaged in a similar work. Science depends on a "multitude of witnesses." The reports we now have, in many instances, give only one or two "supposed" cases, on the strength of which important conclusions are made.

Finally, I must call attention to the fact that this is a report of progress and is partial. The study has not gone far enough to allow of publication of results under the heads of (*bb*), (*c*), (*d*), (*dd*); special bulletins or reports will appear on these subjects as fast as the work is completed. The main object of the present report is to introduce the subject, to record the outline of work, to test the exact value of Koch's lymph and to indicate the rules for its use and the interpretation of "reactions."

In chronologic order, the work progressed as follows:

June 22d, 1893. First examination of Tryntje's milk.
July 14th. First conference with Dr. Pearson.
July 24th. Injection of Tryntje. See Tables, Case 1.

August 11th. Milk from right hind quarter of Tryntje's udder gargety; microscopic examination shows tubercle bacilli.

August 15th—September 15th. During my absence in the West, Mr. Jones observes milk from each separate teat at each milking of Tryntje, and reports at the close of the month that no change in the quality of the milk had taken place. The milk from the one teat remained uniformly "gargety."

October 7th. Second conference with Dr. Pearson. Doubt having been expressed as to the conclusiveness of the evidence presented by my microscopic preparations, I was asked to send sample of milk for study at the Laboratory of Hygiene, under Dr. A. C. Abbott, University of Pennsylvania.

October 9th. Milk sent to Dr. Abbott. Misunderstanding having arisen as to the use to be made of the sample, explanatory correspondence ensued.

October 18th. Dr. Abbott reported that microscopic examination showed presence of tubercle bacilli in said sample of milk.

October 29th. Tryntje gave birth to heifer calf.

November 8th. Tryntje's calf and cow 66 injected, See Table, Cases 2 and 3.

November 9th. Tryntje's calf killed. Dr. H. R. Baldwin, Dr. A. V. N. Baldwin and Mr. E. A. Jones assisted at the autopsy. Specimens preserved as follows: Lung, base of left lung, apex of right lung, thymus gland, submaxillary salivary gland, spleen, mesenteric glands, Peyer's patches, liver, kidney capsule, kidney, small colon. No microscopic lesions visible.

November 10th. Milk from right front quarter of Tryntje's udder becomes gargety. Recommended that samples of milk from different teats be analyzed chemically.

The chemical analysis was made under direction of Dr. E. B. Voorhees, in the State Laboratory, with the following result, comparison being made with normal milk and cases published by A. W. Blyth:

		Solids.	Fat.	Albumens.	Sugar.	Ash.	
Case 1.	Right back teat	6.21	0.20	5.13	0.13	0.75	
	" front "	7.79	1.81	4.33	0.60	1.05	
	Left back "	8.83	1.93	3.92	2.11	0.87	
	" front "	9.79	2.58	3.93	2.24	1.04	
	Cow 73, entire bag.........	15.88	8.11	3.34	3.69	0.74	
Cow A.	Normal milk (Blyth, p. 221)....	water. 86.87	3.50	4.75	4.00	0.70	
Cow B.	Five-year-old cow, right lung tuberculous (Blyth, p. 263)...........	s. gravity. 1.029	2.77	4.51	2.82	0.86	Dates. Dec., '78.
		1.034	3.83	5.76	3.34	0.77	Feb., '79.
Cow C.	Two-year-old cow, advanced phthisis (Blyth, *l. c.*)........................	1.033	2.60	3.00	2.89	0.91	Jan.
		1.033	3.28	4.00	4.10	0.78	Feb.
Cow D.	Cow with tubercular (?) gargety udder (Blyth, *l. c.*)........................	water. 94.64 s. gravity. 1.018	0.49	3.60	0.47	0.76	
			....	....	....	....	

Remarks on above table: Fat content of tubercular milk is progressively reduced. The albumens vary considerably, the main change being in reduction of casein and increase of "albumen" Sugar is greatly decreased, the ash is nearly unchanged, the specific gravity is also reduced. The carbonaceous constituents suffer most change (reduction).

November 15th. Received letter from chairman of Farm Committee stating that Dr. Loblein had examined cow 73 and diagnosed tuberculosis, locating the lung deposit behind the left shoulder. The milk of this cow had been used to feed Fillpail's calf (Case No. 5). Isolation and trial of tuberculin on both the cow and the calf was recommended.

November 16th. Cow 73 injected; showed reaction. See Case 4.

November 30th. Tryntje died this morning. Autopsy held at 3 P. M., at which were present Dr. Austin Scott, Director of the Agricultural College Station; Dr. H. R. Baldwin, Dr. A. V. N. Baldwin, Dr. E. L. Loblein, P. Calydon Cameron and the writer, besides the butcher and farm hands. The following notes were made. Specimens numbered were preserved:

(1) Posterior part right hind quarter of udder, when cut, pus issued from milk ducts. (2) Middle portion of same quarter. (3) Right fore quarter of udder. (4) Left fore quarter of udder. (5) Left hind quarter of udder. (6) Peritoneal tubercle from left side. (7) Tubercles from pleura. (8) Spleen. (9) Omentum [caul]. (10) Small colon near ileocolic valve. (11) Tubercle from small colon. (12) Mesenteric gland near small colon. (54) Left lung. (312) Liver. (119) Kidney. (107) Base of right lung. (68) Muscle tissue, subscapular. The lumen of small intestine and small colon practically obliterated by presence of a large sausage-shaped tubercle that had grown into it. Thoracic and abdominal viscera adhered to pleural and peritoneal walls. Tubercles seen on the meninges of the cerebellum. Part of posterior cerebral lobes also preserved. A heavy, peculiar odor arose from the tissues, which had a very depressing effect on the author and was felt for several days, although he has been accustomed to the dissection of "rank" carcasses.

December 11th. Injected Fillpail's calf, born November 8th, and fed on milk of 66. See Case 5. Calf strong and thrifty.

December 15th. Mr. Jones observed record of calf again without injection. See Case 5*a*.

December 23d. Held autopsies of Cases 3 and 4, Dr. H. R. Baldwin and Dr. E. L. Loblein assisting. For general description, see section 1.

Tag 73. (1) Isolated tubercle from left lung. (2) Thymus gland, tuberculous; mediastinal glands breaking down in center. (3) Apparently healthy tissue from right lung. (4) Right fore quarter of udder. (5) Yellow spot from surface of kidney. (6) Nodules from liver; four months' bull fœtus present preserved, also the amnion and placenta.

Tag 66. Right pleura studded with tubercles, of which (7) is a specimen; left pleura ditto; both lungs tuberculous throughout; anterior and posterior mediastina solid with tubercles. (8) Right front quarter udder. (9) Left front ditto. (10) Right hind ditto. (11) Left hind ditto; liver lead colored, studded with tubercles and tubercle masses all through; bile abnormal. (12) Pedunculated tubercle from liver. (13) Friable tissue of liver. (14) Omental tubercle. (15) Part of small colon.

December 28th. Dr. Loblein begins thorough physical examination of herd.

December 29th. Injected cases 7 to 25, inclusive. See table. Time occupied, P. M. to 8 P. M. One assistant washed the right shoulder, followed by second ssistant, who applied creoline. Two men held the animal in place by means of ails on both sides. Mr. Jones took the temperature. Amount of dose for each case letermined by rough guess at relative size of cow.

January 2d, 1894. Injected cases 26 to 41, inclusive. Time, 6 P. M. to 7 P. M.

January 5th. Received a bottle of milk from cow in herd of George Vandruff,)eckertown, N. J., which differed in no microscopic respect from the "gargety" nilk of Tryntje. At this time I was engaged in certain microscopic investigations earing on the interference of chromatic aberration of bacteria with diagnosis by taining, so did not study this milk microscopically, but determined to visit the erd and test it with tuberculin first. I had hitherto supposed that Tryntje's milk eceived its characters from the presence of tubercle in her udder, but after investi;ating this herd I adopted the opinion that the condition of Tryntje's milk was due o garget, and not to tubercle. The correctness of this view would be somewhat haken should microscopic examination of Tryntje's udder show that tuberculous esions were present only on the right side. At this date this conclusion was not ully matured, and I expected to find evidence of tuberculosis in the Vandruff herd.

January 6th. Asked Mr. Jones to retake the temperatures of cows 11, 68, 244, 4, .6 and 71 without injection. This was done January 9th, and repeated January .0th, making two records for each cow.

January 12th. Held autopsies on cows 15, 13, 39 and 77, being Cases 27, 17, 23 nd 15, respectively, Dr. Loblein directing.

Tag 15, Case 27. Lungs were sound, anterior and posterior mediastinal glands uberculous, liver friable. (1) Inguinal gland. (2) Right hind quarter of udder.

Tag 13, Case 17. Large tubercles in left lung, bronchi filled, mediastinal glands uberculous, liver leaden and friable. (6) Left front quarter of udder. (7) Left iind ditto. (9) Right front ditto. (10) Right hind ditto.

Tag 39, Case 23. Posterior lobe of right lung has large tubercle; many small ubercles attached to pleural membrane of lungs, of which (4) is sample. Small ubercles on and in left lung. Mediastinal glands decidedly tuberculous, liver eaden, friable and with its surface covered with small tubercles. Surface of intesine covered with miliary tubercles. (3) Left front quarter of udder. Eight nonths' fœtus present. (40) Thymus of fœtus.

Tag 77, Case 15. Miliary tubercles on intestines, liver leaden and friable, mediasinal glands with incipient small tubercles, lungs apparently sound. (35) Inguinal gland. (36) Right front quarter of udder. (37) Left front ditto. (38) Right hind litto. (39) Left hind ditto.

Inspected the Vandruff herd, thirteen animals. Six, on physical examination, were supposably sound. Eight were chosen for injection at 9 P. M., each with 50 ninims tuberculin. The herd seems to have been invaded by a disease, either conagious or due to conditions affecting all, or nearly all, the cattle alike. Swellings iad appeared at the joints of the legs, the coat was rough, considerable coughing was heard, one or more of the quarters of the udders had swollen and the milk had become wheyey, with clots. In fact, the symptoms of garget were typically exhibited, together with pneumonic troubles. The disease had come and subsided in some of the cases, and at times re-appeared. The attack had begun with the advent of cold

weather. One animal, sick in November, had been purged and was found dead next morning. This was dug up and an examination of its lungs made, January 13th, 3 P. M. These organs were in a highly-inflamed and congested condition, being dark purple in color, but showed no lesions of a tubercular nature. In detail, the animals injected were as follows: Black heifer, sound; range, 2.5°. Jumbo, left front quarter first affected two months before; still somewhat hard, but milk all right again; on auscultation, heard slight murmur; range, 1.2°. Yellow heifer, left hind quarter of udder began to show signs of disease December 22d; the swelling has disappeared from the legs; the left hind quarter of udder is still hard; no especial sounds heard on auscultation; range, 1.4°. Gray heifer, left front and left hind quarters of udder have been affected six weeks; legs had been swollen and bowels loose; slight murmurs heard on right side; range, 1.6°. Ollie is lean, coughs a good deal, muzzle ' sweats;" entire udder enormously swollen and hard; cow lies down a great deal; legs not swollen, hair rough; initial temperature, 103.2°, is highest; range, 1.2°; samples of milk secured; respiratory murmurs very strong; evident lung trouble; record resembles that of Tryntje, and many physical signs seem to point to same conclusion; nevertheless, did not diagnose a case of tuberculosis, owing to the records shown by other cows and the evidence for garget and pneumonia. I reasoned that probably one affection was present. The absence of tubercular reactions from the other sick members as well as from Ollie, shows that tuberculosis is not present in the herd, for if present, the likelihood would be that all cows would have it and some reaction would be shown. Hence, the high initial temperature of Ollie points to the presence of a disease other than tuberculosis. Brown cow, whole udder swollen; right hind quarter hard, pressure causes shrinking; left horn is warmer than right; left hock is swollen and painful; range, 0.2°. Star cow, right side and left hind quarter of udder swollen and hard; respiratory soughing heard; range, 2.1°; the initial temperature, 102.1, is highest. Brindle, was very bad, but now the milk is coming down; the legs were sore and swollen; now much better; range, 0.8°.

The temperatures of these cows were taken at 9 to 10 in the evening, before injection, again at 6 in the morning, at 9:30 A. M., at 2:30 P. M. and at 4 P. M. (See Table XVI., at close of this report.)

In February, a letter from Mr. Vandruff tells us that there has been slow improvement and only in case there is a decided change for the worse will he consent to have a cow killed, without compensation, by the National Bureau of Animal Industry, which has become interested in the case through notice given by Dr. Hunt, Secretary of the New Jersey State Board of Health.

January 15th. Held autopsy on cow 6. Case No. 39. Left lung, anterior lobe, has a large tubercle. (1) Small tubercles on ventral lobe of right lung; liver leaden, friable with tubercles on surface and within it. Mediastinal glands greatly enlarged and tuberculous; numerous miliary tubercles on small intestines. (41) Right front quarter of udder. (43) Left front ditto. (44) Right hind ditto. (45) Left hind ditto. (5) Small intestine.

Fillpail's calf (Case 5) autopsied in the afternoon, shows no macroscopic lesions of tubercle. (11) Glands from ileum near ileo-colic valves. (12) Thymus. (13) Posterior mediastinal gland. (14) Anterior mediastinal gland. (15) Encysted blood clot (?) on stomach. Also a dark lymph gland from liver preserved.

January 16th. Autopsied cows 51, 8, 5 and 71, *i. e.* Cases 40, 19, 18 and 36. Dr. Loblein, examiner.

Cow 51, Case 40. Several incipient tubercles found on all three lobes of left lung; mediastinal glands apparently sound, liver slightly leaden. (68) White spot on liver. (55) Posterior mediastinal gland. (64) Lung. (56) Mesenteric gland, also (o). (70) Peyer's patch.

Cow 8, Case 19. Left lung with incipient tubercles, right, marbled, pneumonic; posterior mediastinal glands tuberculous, yellowish green; liver apparently sound; five months' fœtus present. (28) Small intestine. (51) Left front quarter of udder. (59) Left hind ditto. (63) Right hind ditto. (66) Right front ditto.

Cow 5, Case 18 Congested area on right lung, posterior mediastinal glands tuberculous, right side of udder at base, tuberculous; miliary tubercles on intestine and liver; seven months' fœtus present. (71) Inguinal gland. (27) Left hind quarter of udder. (61) Left front ditto. (50) Right hind ditto. (52) Right front ditto. (23) Thymus of fœtus.

Cow 71, Case 36. Inflammations and miliary tubercles on pleura of ribs, left side; mediastinal glands extremely hypertrophied, with tuberculous deposits; large tubercles on superior part of anterior lobe, right lung, while posterior lobe of same side presents gangrenous and congested condition, with miliary tubercles; left lung more tuberculous than the right; pancreas appeared abnormal; liver is tuberculous, and some miliary tubercles present on the intestine; three months' fœtus present. (60) Pancreas. (17) Left hind quarter of udder. (58) Left front quarter. (21) Right hind ditto. (19) Right front ditto.

January 20th. Autopsies of cows 9, 12 and 16, Cases Nos. 14, 12 and 28, Dr. Loblein assisting.

Cow 12, Case 12. Posterior mediastinal glands tuberculous; anterior apparently absent or rudimentary; lungs apparently sound; liver leaden, has large tubercles; ovaries abnormal; miliary tubercles on intestine. (53) Left ovary. (16) Right hind quarter of udder. (83) Left hind ditto. (88) Right front ditto. (91) Left front ditto. (62) Bronchial gland.

Cow 9, Case 14. Posterior lobe of left lung very tuberculous; liver apparently healthy; miliary tubercles on small intestine; left ovary abnormal; mediastinal glands rudimentary; apparently garget-like condition in left hind quarter of udder. (20) Left hind quarter. (84) Left front ditto. (22) Right front ditto. (87) Right hind ditto. (26) Left ovary. (25) Small intestine.

Cow 16, Case 28. Posterior mediastinal glands tuberculous, and one broken down in center to fluid condition; spot on lung congested and gangrenous; pimples (miliary tubercles?) on colon; abnormal growth on left ovary. (33) Udder. (86) Broken-down mediastinal gland. (57) Posterior mediastinal gland. (89) Congested part of lung. (18) Lymphatic gland from stomach. (32) Tubercle pimple from colon. (65) Small intestine, with pimples. (69) Colon, with pimples. (54) Left ovary. (29) Upper part of Fallopian tube.

January 22d. Autopsies held on cows 68, 244, 56 and 4, Cases 20, 21, 32 and 25.

Cow 68, Case 20. Lungs sound, bronchial glands tuberculous, miliary tubercles on intestine. (94) Right front quarter of udder. (115) Right hind ditto. (103) Left hind ditto. (82) Left front ditto. (104) Bronchial gland. (24) Left ovary. (98) Right ovary.

Cow 244, Case 21. Posterior cephalic lobe of right lung one mass of small tubercles; posterior mediastinal glands tuberculous. (110) Right hind quarter of udder. (92) Right front ditto. (113) Left hind ditto. (106) Left front ditto. (107) Inguinal gland. (96) Left ovary. (85) Right ovary.

Cow 56, Case 32. Large tubercles on principal lobe of left lung; bronchial and mediastinal glands highly tuberculous; tuberculous (?) papillæ on intestine; left ovary bears papillæ that require investigation; very large tubercle in dorsal mediastinum, near diaphragm. (111) Inguinal gland. (67) Left front quarter of udder. (101) Left hind ditto. (109) Right front ditto. (80) Right hind ditto. (93) Intestinal papilla. (31) Left ovary. (102) Right ovary.

Cow 4, Case 25. Very fat; inguinal glands perhaps abnormal; dorsal mediastinal glands very tuberculous; right lung a mass of small tubercles; liver abnormally soft and leaden; miliary tubercles on intestine; twin fœtuses present in uterus. (105) Left hind quarter of udder. (114) Left front ditto. (112) Right front ditto. (108) Right hind ditto. (97) Inguinal gland. (81) Intestine. (100) Right ovary. (99) Left ovary.

February 5th. Autopsy of cow 11 (Case 16) imperfect, due to ignorance of butcher, who failed to keep the parts most needed for examination; no responsible parties being present during the slaughter. The butcher reported pleural adhesions of lung walls. A portion of lungs recovered failed to show macroscopic tuberculous lesions. (A) Bronchial gland. (AA) Part of lung.

February 6th. Writer and Mr. Jones present during slaughter of cow 75 (Case 13). Principal lobe of right lung showed large tubercles (size of a fist); mediastinal glands tuberculous, inguinal glands enlarged; no macroscopic tuberculous lesions seen on section. (B) Left hind quarter of udder. (C) Inguinal gland. (D) Small bronchial gland.

February 8th. Lungs and inguinal glands of cow 17 (Case 26) were brought to the laboratory by Mr. E. A. Jones. He reported that he saw no tubercles on the intestines. Examination of material brought showed inguinal glands rather larger than normal, but on section no tuberculous lesions visible; lungs were apparently sound. Samples preserved were marked XVII.

February 15th. Dr. Loblein injected 52 and 53 (Cases 42 and 43), the results plainly showing a reaction with 52 and a doubtful reaction with 53.

February 24th. Lungs of 52 (Case 42) and liver and lungs of 2 (Case 8) left by Mr. Jones to be examined at the laboratory; animals killed the day before.

Cow 2 (Case 8) showed extreme tuberculosis of the brochial glands; milk taken, but udder was thrown away. Liver congested and with incipient tubercles. (2*a*) Liver.

Case 42. Mr. Jones reported that the lungs and intestines had been examined by him and no lesions discoverable. Dr. Loblein joined me in examination of these lungs. Near the surface were local areas of superficial inflammation, in which were very small tubercles, with cheesy deposits in their centers. The bronchial glands presented small pus (?) cavities within. (52*a*) Lung tissue. (52*b*) Bronchial gland. Samples for desiccation also taken.

February 28th. Mr. Jones brought portions of intestine, udder, liver and lungs of 55 (Case 24) to the laboratory. On posterior part of main lobe of right lung, a spherical tubercle of the size of a hazelnut was found, otherwise the lungs appeared sound; liver was peculiarly pitted, otherwise tuberculous lesions appeared absent; the intestines were well covered with miliary tubercles the size of small peas and caseous in center. Samples preserved.

§ 4. *Summaries of Data, Tables and Discussion of Same.*

Milk has been preserved from the four teats, separately, in the cases of cows 66, 77, [Ollie, yellow heifer, brown heifer and Jumbo, of Vandruff herd], 6, 8, 71, 5, 14, 20, 9, 30, 25, 22, 23, 56, 4, 68, 244, 2 and 55, or more than twenty cases.

Fœtuses have been found in cows 73, 39, 8, 5, 71, 4, and Tryntje and Fillpail also had each a calf that were used in feeding experiments.

Excluding the bull and a cow sold early in the season of experimentation and including the tuberculous cow slaughtered early in August, and the heifers and calves, 43 animals are to be counted as included in this investigation, and of these, 28 animals have been under autopsy, in which two calves and two cows did not show macroscopic tuberculous lesions and are therefore still in doubt; the others were decidedly tuberculous. The temperature records of the calves and the doubtful cows are in themselves not decisive, although running as high as some cases showing decided tuberculosis, but every case of undoubted reaction proved to be undoubtedly tuberculous, whether diagnosed "suspicious" or as "O. K." by physical examination. These and other facts become more strikingly apparent from inspection of the succeeding tables.

TABLE I.

College Farm Herd, Injected December 29th and January 2d, 1893-94.

Number of Case.	Dose—Minims.	THEORETICAL PERIODS. Initial Temperature. 5-8 p. m.	3 hours. Period I. 2-4 hours. 8-10 p. m.	6 hours Period II. 5-8 hours. 12-2 a. m.	9 hours. Period III. 8-11 hours. 2-4 a. m.	12 hours. Period IV. 11-13 hours. 5-7 a. m.	15 hours. Period V. 15-18 hours. 7-11 a. m.	18 hours. Period VI. 18-19 hours. 12-2 p. m.	21 hours. Period VII. 20-22 hours. 2-4 p. m.	24 hours. Period VIII. 24-25 hours. 6-7 p. m.	Range.	Rise from Initial Temperature.	Maximum Temperature.	Time to Maximum Temperature.	Time of Maximum Temperature.
1	80	8 p. m. 103.35°	10 p m. 103.1°	12:30 p. m. 103.2°	3 a. m. 102.2°	5 a. m. 102.2°	7:15 a. m. 101.2°	11:30 a. m. 102.0°	......	......	1.2	—1.2	103.35	hrs. 0	8 p. m.
2	20	6 p. m. 102.6	8:45 p. m. 102.8	......	2 a. m. 103.2	5 a. m. 103.2	7:15 a. m. 104.0	12 m. 104.8	4 p. m. 103.6°	......	2.2	2.2	104.8	18	12 m.
3	50	6:30 p. m. 102.5	8.55 p. m. 103.4	......	106.3	106.3	7:30 a. m. 105.8	103.0	103.3	......	3.8	3.8	106.3	8	5 a. m.
4	40	5 p. m. 102.4	8 p. m. 103.4	......	105.0	104.4	8 a. m. 105.8	106.0	3:30 p. m. 105.0	6 p. m. 105.8°	3.6	3.6	106.0	18	12 m.
5	15	5:30 p. m. 103.0	9 p. m. 101.8	......	104.2	104.6	9 a. m. 104.0	104.5	4 p. m. 103.6	......	2.8	1.6	101.6	12	5 a m.
*5a	0	6 p. m. 101.8	10 p. m. 102.0	......	101.6	5:30 a. m. 101.8	......	......	......	......	0.4	0.2	102.0	4	10 p. m.
7	50	6:15 p. m. 101.8	9 p. m. 101.2	1 a. m. 101.0	......	100.0	9 a. m. 101.4	1 p. m. 100.7	4 p. m. 101.1	6:30 p. m. 100.5	1.8	—1.8	101.8	0	6 p. m.
8	40	100.0	100.8	100.0	......	100.8	102.6	103.1	102.4	101.7	3.1	3.1	103.1	18	1 p. m.
9	60	100.6	99.2	100.0	......	101.0	101.0	101.4	102.6	100.0	3.4	2.0	102.6	22	4 p. m.
10	45	6:30 p. m. 102.2	101.4	101 2	......	101.8	102.0	100.2	102 6	101.8	2.4	0.4	102.6	22	4 p m.
11	80	102.4	100.6	98.0	......	99.8	101.0	99.6	100.0	100.8	4.4	—4.4	102.4	0	6:30 p. m.
12	55	100.0	101.2	100.8	......	104.6	104.6	105.2	105.2	104.2	5.2	5.2	105.2	18	1 p. m.
13	50	101.4	100.2	100.0	......	100.8	101.6	102.7	103.4	101.8	3.4	2.0	103.4	22	4 p. m.
14	55	102.0	101.0	101.8	......	105.4	104.5	103.7	101.5	101.2	4.4	3.4	105.4	12	6 a. m.
15	45	101.2	100.6	100.6	......	103.6	105.2	105.3	104.0	103.3	4.7	4.1	105.3	18	1 p. m.
16	60	7 p. m. 100.4	101.6	98.4	......	100.4	101.2	103.6	102.0	103.4	5.2	3.2	103.6	18	1 p. m.
17	60	100.2	101.0	101.8	......	106.5	106.0	105.5	105.0	105.2	6.3	6.3	106.5	12	6 a. m.
18	50	100.0	99.8	101.8	......	103.2	104.9	105.0	106.2	105.0	6.4	6.2	106.2	22	4:30 p. m.
19	40	7:15 p. m. 100.2	10 p. m 100.6	2 a. m. 100.4	......	6:30 a. m. 104.3	10 a. m. 104.8	2 p. m. 104.6	5 p. m. 105.4	7:30 p. m. 103.5	5.2	5.2	105.4	22	5 p. m.

* Not under influence of injection.

20	50	100.4°	100.2°	101.0°	......	101.6°	104.2	101.4	100.4	100.2	4.0	3.8	104.2	15	10 a. m.
21	50	100.6	101.0	102.4	......	104.6	104.1	102.5	101.2	101.5	4.0	4.0	104.6	12	6:30 a. m.
		7:30 p. m.													
22	50	100.8	101.4	100.6	......	100.9	101.2	99.4	99.7	100.5	2.0	0.6	101.4	3	10 p. m.
23	50	101.2	101.2	101.2	......	105.2	105.8	105.6	104.8	103.0	4.6	4.6	105.8	15	10 a. m.
24	50	99.4	101.2	98.8	......	98.6	100.0	102.3	102.2	101.0	3.7	2.9	102.3	18	2 p. m.
		7:45 p. m.	10:20 p. m.	2:30 a. m.		6:40 a. m.	10:20 a. m.		5:20 p. m.	7:50 p. m.					
25	60	100.6	100.6	100.6	......	102.4	104.0	104.3	104.4	103.4	3.8	3.8	104.4	22	5 p. m.
		6:15 p. m.	8:30 p. m.	12:30 a. m.		5:30 a. m.	10:30 a. m.		2:30 p. m.	6 p. m.					
26	40	102.2	102.4	104.0	......	102.0	101.5	......	103.8	101.8	2.3	1.6	104.0	6	12:30 a. m.
27	45	102.1	102.0	103.0	......	105.2	106.1	......	106.8	104.1	4.8	4.7	106.8	20	2:30 p. m.
28	45	101.3	101.8	101.8	......	103.5	104.0	......	104.0	101.8	2.7	2.7	104.0	15	11 a. m.
29	50	101.2	101.2	100.0	......	100.7	100.6	......	101.0	100.5	1.2	—1.2	101.2	0	6 p. m.
30	50	101.5	101.0	98.0	......	100.0	100.4	......	101.0	101.0	3.5	—3.5	101.5	0	6 p. m.
31	50	101.6	101.7	101.4	......	101.4	101.2	......	101.3	101.1	0.6	—0.5	101.7	2	9 p. m.
32	50	101.5	101.0	100.8	......	101.8	105.0	......	104.5	103.8	4.2	3.5	105.0	16	11 a. m.
33	55	102.0	101.2	101.4	......	101.2	100.7	......	101.6	101.1	1.3	—1.3	102.0	0	7 p. m.
34	55	101.2	101.2	100.6	......	101.2	101.0	......	101.2	101.2	0.6	—0.6	101.2	0	7 p. m.
		6:45 p. m.	9 p. m.	1 a. m.		6 a. m.	11 a. m.		3 p. m.	6:30 p. m.					
35	55	101.6	101.7	101.6	......	101.3	101.6	......	101.8	101.3	0.5	0.2	101.8	20	3 p. m.
36	50	101.0	101.6	100.6	......	103.6	105.1	......	103.5	103.7	4.5	4.1	105.1	16	11 a. m.
		6:50 p. m.	9:10 p. m.	1:10 a. m.		6:10 a. m.	11:10 a. m.		3:10 p. m.	6:40 p. m.					
37	55	101.7	101.7	100.0	......	101.4	101.7	......	101.2	102.0	2.0	0.3	102.0	0	7 p. m.
38	40	101.3	101.0	100.8	......	100.0	101.7	......	100.8	100.6	1.7	0.4	101.7	16	11 a. m.
39	40	100.6	101.4	101.6	......	102.8	103.0	......	102.0	101.6	2.4	2.4	103.0	16	11 a. m.
40	20	101.8	101.4	101.6	......	105.5	105.5	......	105.0	104.2	4.1	3.7	105.5	12	6:30 a. m.
		7 p. m.	9:30 p. m.	1:30 a. m.		6:30 a. m.	11:30 a. m.		3:30 p. m.	7 p. m.					
41	20	101.9	101.4	101.4	......	101.3	101.6	......	101.2	101.3	0.7	—0.7	101.9	0	7 p. m.
		10 a. m.			6 p. m.	8:30 p. m.	10:30 p. m.								
42	......	101.0	......	......	104.2	106.2	105.7	......	......	......	5.2	5.2	106.2	12	8:30 p. m.
43	......	100.8	......	......	102.4	102.7	101.5	......	......	......	1.9	1.9	102.7	12	8:30 p. m.
		8 p. m.				6 a. m.	9 a. m.	12:15 p. m.	3:15 p. m.	5:15 p. m.					
44	......	101 0	......	......	......	101.2	101.6	101.5	101.5	101.2	0.5	0.6	101.6	13	9 a. m.
		8:30 p. m.				6:30 a. m.	9:30 a. m.	1 p. m.		6:30 p. m.					
45	......	101.2	......	......	......	101.2	101.7	98.6	......	101.3	3.1	0.5	101.7	13	9:30 a. m.
46	......	101.7	......	......	......	101.7	102.0	100.0	......	101.9	2.0	0.3	102.0	13	9:30 a. m.
		7 p. m.				6:30 a. m.	9:30 a. m.	12:30 p m.		5 p. m.					
47	......	101.2	......	......	......	101.2	102.0	98.6	......	102.1	3.5	0.9	102.1	15	5 p. m.
48	......	101.3	......	......	......	101.2	102.5	100.8	......	101.8	1.7	1.2	102.5	15	9:30 a. m.
49	......	99.5	......	......	......	100.4	101.3	99.5	......	100.4	1.8	1.8	101.3	15	9:30 a. m.
50	......	100.7	......	......	......	100.7	101.3	101.5	......	101.2	0.8	0.8	101.5	18	12:30 p. m.
		8 a. m		2:30 p. m.	5:30 p. m.	8,30 p. m.	11:30 p. m.	2:30 a. m.		8 a. m.					
9*ii*.	......	101.0	......	101.9	100.4	100.2	100.6	100.6	......	100.9	1.7	0.9	101.9	6	2:30 p. m.

EXPLANATION OF TABLE I.

The eight periods of three hours each cover the night and day, twenty-four hours in all; but, of course, it was impossible to inject and to observe all the cows simultaneously, so that there is some departure from fixed hours. The earlier cases were not observed with the regularity of the later ones. Cases 42 to 50 were injected by Dr. E. L. Loblein, the last eight cases being the new cows added to the herd to date of beginning work on this report. Case 9*ii* is case 9 injected a second time. Case 5*a* properly belongs to Table III., but does not fit into its period so well as here. Dotted lines represent absence of observation. The column headed "rise from initial temperature" is the "approximate reaction" as usually calculated. When a minus sign precedes a number in this column it represents a fall from initial evening temperature, calculation being made to the lowest record; thus the range and negative reaction are the same. For dates of injection see later tables.

TABLE II.

Showing College Herd, With Data From Autopsies, Etc.

Tag Number.	Number of Case.	NAME OF ANIMAL.	Breed.	Age.	Source.	How Long at Farm.	Result of Physical Examination.	Least Total Reaction.	Diagnosis by Koch Test.	Highest Maximal Excess.	RESULT OF AUTOPSY. THORAX Lungs and Pleura.	THORAX Glands.	ABDOMEN. Liver.	ABDOMEN. Intestines.	ABDOMEN. Etc.	Total Tuberculosis.
1	1	Tryntje No. 2	Holstein	9 yrs.	U. P.	2 yrs. 4 mos.	Tuberc	8	Probably Tuberc.	1.4	24	6	6	+6	6	48
.....	2	Tryntje's Calf	Jersey Holstein	1 mo.	Bred	1 mo.	O. K.	27	Reaction	3.2	.....	1	.....	1	.....	2
66	3	Maria Starr	Holstein	10 yrs.	G. W. T.	2 yrs. 8 mos.	Tuberc	47	Tuberc.	4.3	16	4	4	4	1	29
73	4	Marion Perkins	Shorthorn	2 yrs.	Bred	2 yrs.	Tuberc	72	Tuberc.	4.4	9	5	3	2	2	21
.....	5	Fillpail's Calf	Jersey Holstein	9 weeks	Bred	9 weeks	O. K.	32	Reaction	2.6	.....	1	.....	1	.....	2
3	7	Rose Eola	Ayrshire	9 yrs.	C. M. W.	2 yrs. 2 mos.	Suspected	.....	O. K.	.....	.....	.....	.....	.....	.....	.....
2	8	Mary Gold	Ayrshire	13 yrs.	J. O. M.	2 yrs. 1 mo.	O. K.	9	Probably Tuberc.	1.6	?	5	2	.....	.....	7
10	9	Woodland Caphea	Holstein	7 yrs.	G. W. T.	2 yrs 8 mos.	Suspected	+1	Possibly Tuberc. (?)	.4	.....	.....	.....	.....	.....	.....
14	10	Edith Thompson	Holstein	2 yrs. 6 mos.	Bred	2 yrs. 6 mos.	O. K.	+1	Possibly O. K. (?)	.4	.....	.....	.....	.....	.....	.....
69	11	Jessie Lorita	Native	10 yrs	D. H. V.	2 yrs. 11 mos.	O. K.	.....	Probably O. K.	.....	.....	.....	.....	.....	.....	.....
12	12	Fillpail	Shorthorn	12 yrs.	S. S.	2 yrs. 2 mos.	Suspected	59	Tuberc.	3.6	0	3	4	4	3	14
75	13	Chloe	Holstein	12 yrs	M. P.	2 yrs. 9 mos.	.....	7	Probably Tuberc.	1.2	7	3	.....	.....	.....	10
9	14	May Murray	Holstein	9 yrs.	T. C.	1 yr. 2 mos.	Suspected	30	Tuberc.	3.4	5	0	0	4	2	11
77	15	Miss Cornelia 8th	Ayrshire	7 yrs.	L. S. D.	2 yrs. 2 mos.	Doubt	45	Tuberc.	3.7	0	2	3	4	.....	9
11	16	Kitty Clay 2d	Shorthorn	10 yrs.	S. S.	2 yrs. 3 mos.	Suspected	5	Probably Tuberc.	2.0	?	.....	.....	.....	.....	?
13	17	Chautauqua Bell	Shorthorn	6 yrs.	S. S.	1 yr. 3 mos.	Suspected	84	Tuberc.	5.5	4	4	3	.....	.....	11
5	18	Lily Champion	Jersey	9 yrs.	J. O. C.	2 yrs.	O. K.	73	Tuberc.	4.0	1	3	4	4	3	15
8	19	Bertha Hadley	Guernsey	6 yrs.	W. A. R.	1 yr. 11 mos.	Tuberc.	58	Tuberc.	3 6	3	3	0	.....	.....	6
68	20	Kate Daly	Native	8 yrs.	P. D.	8 mos.	O. K.	8	Tuberc.	2.8	0	3	.....	4	.....	7
244	21	Ada Neilson	Holstein	9 yrs.	J. N.	2 yrs. 9 mos.	Tuberc	28	Tuberc.	3.6	4	3	.....	.....	.....	7
72	22	Winifred	Shorthorn Grade	2 yrs.	Bred	2 yrs. 1 mo.	O. K.	70	O. K.	.....	.....	.....	.....	.....	.....	.....
39	23	Miss Thompson	Holstein	9 yrs.	G. W. T.	2 yrs. 9 mos.	Bronchitis	70	Tuberc.	4.0	9	4	3	4	.....	20
55	24	Rena	Native	7 yrs.	D. H. V.	2 yrs. 11 mos.	O. K.	4	Probably Tuberc.	.7	2	.....	1	5	.....	8
4	25	Grace Buttercup	Jersey	9 yrs.	A. H. C.	2 yrs. 6 mos.	Suspected	38	Tuberc.	2.7	5	5	2	4	.....	16
17	26	Kitty Clay 3d	Shorthorn	2 yrs. 4 mos.	Bred	2 yrs 4 mos.	.....	33	Probably Tuberc.	2.2	0	.....	.....	.....	?	?
15	27	Hulda Chloe	Holstein	1 yr. 11 mos.	Bred	1 yr. 11 mos.	O. K.	65	Tuberc.	4.6	0	4	3	.....	.....	7
16	28	Carrie Darlington	Jersey	1 yr. 7 mos.	Bred	1 yr. 7 mos.	.....	20	Tuberc.	1.8	1	4	.....	3	3	11
61	29	Dolores	Native	9 yrs.	P. D.	9 mos.	O. K.	.....	O. K.	.....	.....	.....	.....	.....	.....	.....
62	30	Pauline	Grade Holstein	9 yrs.	D. H. V.	2 yrs. 11 mos.	O. K.	.....	Probably O. K.	.....	.....	.....	.....	.....	.....	.....
58	31	Marjory	Native	6 yrs.	P. D.	10 mos.	O. K.	.....	O. K.	.....	.....	.....	.....	.....	.....	.....

TABLE II.—Continued.

Showing College Herd, With Data From Autopsies, Etc.

Tag Number.	Number of Case.	Name of Animal.	Breed.	Age.	Source.	How Long at Farm.	Result of Physical Examination.	Least Total Reaction.	Diagnosis by Koch Test.	Highest Maximal Excess.	Result of Autopsy. Thorax: Lungs and Pleura.	Thorax: Glands.	Abdomen: Liver.	Abdomen: Intestines.	Abdomen: Etc.	Total Tuberculosis.
56	32	Topsy	Grade Holstein	6 yrs.	G. W. T.	2 yrs. 10 mos.	O. K.	31	Tuberc.	2.5	4	5	......	4	3	16
74	33	Ella Thompson	Holstein	2 yrs. 11 mos.	Bred	2 yrs. 11 mos.	O. K.	......	O. K.	......	......	......	......	......	......	......
*O	34	Gladys	Native	8 yrs.	F	1 yr. 4 mos.	Suspected	......	O. K.	......	......	......	......	......	......	......
63	35	Estelle	Native	7 yrs.	V.	1 yr. 11 mos.	O. K.	......	O. K.	......	......	......	......	......	......	......
71	36	Miss Kicker	Native	10 yrs	D. H. V.	1 yr. 3 mos.	O. K.	43	Tuberc.	3.1	13	5	3	3	2	26
59	37	Maruja	Grade Holstein	6 yrs.	G. N.	3 yrs. 2 mos.	......	......	O. K.	......	......	......	......	......	......	......
8	38	Mollie Sebolt	Jersey	6 yrs.	J. S.	2 mos.	......	......	O. K.	......	......	......	......	......	......	......
6	39	Lily of Orange	Guernsey	10 yrs	L. P. M.	1 yr. 11 mos.	Doubt	14	Probably Tuberc	1.8	6	5	4	4	......	19
51	40	Rose Eola 2d	Grade Ayrshire	9 mos	Bred	9 mos	......	50	Tuberc	3.7	3	0	1	......	......	4
54	41	Florence Buttercup 2d.	Jersey	9 mos	Bred	9 mos	......	......	O. K.	......	......	......	......	......	......	......
52	42	Bertha Ladd	Guernsey	9 mos	Bred	9 mos	......	63	Tuberc	4.0	2	1	......	......	......	3
53	43	De Gale Orange	Guernsey.	9 mos	Bred	9 mos	......	+1	O. K. (?)	.5	......	......	......	......	......	......

* No tag.

EXPLANATION OF TABLE II.

This table gives tag and name, the breed and age of the cows in the herd. The column headed "source" gives the initials of the man from whom the cows were bought, the locality of his residence being reserved for later tables. The next column shows how long the cows have been at the College farm, then follow the results of physical examination.

The succeeding columns were calculated from the temperature figures and the autopsies. The first three columns have been borrowed from tables to be hereafter discussed, and need not now receive further attention; the columns under "result of autopsy" were calculated as follows:

0=no tubercle.
1=suspected microscopical tuberculosis.
2=incipient tuberculosis.
3=several small or few large tubercles.
4=miliary tuberculosis, many large, or very many small tubercles.
5=thoroughly-advanced tuberculosis of an organ, seriously injuring its functions
6=extreme tuberculosis; on the verge of death.

Each lung and each pleuron counted as a separate organ, the thoracic lymphatic glands, the liver, the intestinal canal and mesenteries, spleen, caul, etc., and finally the ovaries, kidneys, etc., each received counts by itself—judged on the above scale—and the sum is the "total tuberculosis"—necessarily rough, and not so valuable as if we had given the values at the time of autopsy, this evaluation will still help to give indications of a general nature in succeeding studies.

TABLE III.

Temperatures of Tuberculous Cows After Influence of Tuberculin Has Ceased.

Number of Case.	DATE.	Period IV. 5:30 a. m.	Period V. 9 a. m.	Period VI. 12 m.	Period VII. 4 p. m.	Period VIII. 6 p. m.	Range.	Maximum Temperature.	Time of Maximum Temperature.	Rise from Period VIII.	Amount of Tubercle.
16*a*	January 9	99.5	100.6	99.8	100.6	98.0	2.6	100.6	9 a. m.	2.6	?
16*b*	" 10	100.0	100.2	......	101.0	100.2	1.0	101.0	4 p. m.	0.8	......
16*c*	" 23	99.0	101.3	100.4	100.5	100.0	2.3	101.3	9 a. m.	1.3	......
16*d*	" 24	100.6	99.9	99.9	100.8	101.0	1.1	101.0	6 p. m.	—1.1	......
20*a*	" 9	98.9	101.2	100.5	100.6	100.7	0.7	101.2	9 a. m.	0.5	7
20*b*	" 10	101.0	100.9	......	100.7	100.6	0.8	100.9	9 a. m.	0.3	......
21*a*	" 9	100.4	101.4	101.3	100.9	101.1	0.5	101.4	9 a. m.	0.3	7
21*b*	" 10	100.4	101.1	......	100.0	100.5	1.1	101.1	9 a. m.	0.6	......
25*a*	" 9	100.1	101.0	101.2	100.8	100.3	0.9	101.2	12 m.	0.9	16
25*b*	" 10	100.0	100.7	......	100.6	100.9	0.9	100.9	6 p. m.	Fall.	......
28*a*	" 9	100.0	101.0	100.4	100.9	100.2	1.0	101.0	9 a. m.	0.8	11
28*b*	" 10	100.6	100.8	......	100.7	98.0	2.8	100.8	9 a. m.	2.8	......
36*a*	" 9	100.0	100.9	100.8	100.8	100.3	0.8	100.9	9 a. m.	0.6	26
36*b*	" 10	100.0	100.7	......	100.5	101.0	1.0	101.0	6 p. m.	Fall.	......
26*a*	" 23	100.4	100.3	100.4	101.7	101.6	1.4	101.7	4 p. m.	0.1	1
26*b*	" 24	100.4	101.4	101.5	101.9	102.3	1.9	102.3	6 p. m.	Fall.	......
13*a*	" 23	100.4	100.7	100.4	101.0	101.0	0.6	101.0	4 p. m.	Fall.	10
13*b*	" 24	100.0	101.0	100.0	100.2	101.4	1.4	101.4	6 p. m.	Fall.	......
8*a*	" 23	100.7	100.6	100.7	100.7	100.6	0.1	100.7	12 m.	0.1	7
8*b*	" 24	100.2	101.8	102.5	102.5	102.0	1.3	102.5	12 m.	0.5	......
24*a*	" 23	99.8	98.5	98.5	99.7	99.6	1.3	99.8	6 a. m.	0.2	8
24*b*	" 24	99.7	100.6	100.1	99.0	100.0	1.6	100.6	9 a. m.	0.6	......
*5*a*	......	......	......	......	......	......	......	......	......	......	......

* See Table I.

TABLE IV.

Temperatures of Non-reacting Cows After Influence of Tuberculin Has Ceased.

Number of Case.	DATE.	Period IV. 5:30 a. m.	Period V. 9 a. m.	Period VI. 12 m.	Period VII. 4 p. m.	Period VIII. 6 p. m.	Range.	Maximum Temperature.	Time of Maximum Temperature.	Rise from Period VIII.
9*a*	January 23	100.7	100.5	100.2	100.5	100.4	0.5	100.7	6 a. m.	0.3
9*b*	" 24	100.9	101.2	100.7	101.0	100.8	0.5	101.2	9 a. m.	0.4
10*a*	" 23	101.2	101.2	101.0	101.2	101.0	0.2	101.2	6 a. m.	0.2
10*b*	" 24	101.6	101.9	101.1	101.3	101.8	0.8	101.9	9 a. m.	0.1
11*a*	" 23	99.9	100.0	99.1	99.9	100.8	1.7	100.8	6 p. m.	Fall.
11*b*	" 24	100.0	100.7	99.7	102.2	100.7	1.0	100.7	6 p. m.	Fall.
30*a*	" 23	100.5	100.8	100.5	101.2	100.6	0.7	101.2	4 p. m.	0.6
30*b*	" 24	100.5	100.8	100.7	101.0	101.0	0.5	101.0	4 p. m.	Fall.

EXPLANATION OF TABLES III. AND IV.

Table III. gives the temperatures of cases at first considered doubtful in their reaction, taken after the influence of the injection has ceased and for two days, the hours chosen being those at which the apparent reaction took place. By comparison with the corresponding temperatures under Table I., we can gain important information as to the presence of reaction. As will be seen, reaction took place in every case, and the autopsies justify the conclusion. The "approximate reaction" (that is, the difference between initial evening temperature and the maximum, though, of course, no real *reaction* can be present in absence of injection) could in these cases be calculated from the evening temperature at close of day. Of course, this is just as allowable as to use the temperature of the evening of the previous day, as is ordinarily done. It could be used in tubercular cases, except that the reaction often lasts over into the night, thus disturbing this temperature; but, as a rule, previous observers have not extended their observations to the second evening. Cases 9 and 10 of Table IV. seem to show small reaction, and have, therefore, been included with reacting cases in subsequent tables.

TABLE V.

Cases Arranged in Order of Absolute Height, Giving Class, According to Koch Test, Based on Height, Apparent Reaction and Range.

Tag.	Case.	Rise above 100°.	Range.	Diagnosis by the Koch Test.	Rise above Initial Temperature.	Diagnosis by Physical Examination.	Date of Injection.	Amount of Tubercle.	Date of Autopsy.	Total Reaction.
15	27	6.8	4.8	Decidedly Tuberculous	4.7	O. K.	January 2	7	January 12	65
13	17	6.5	6.3	" "	6.3	Suspected	December 29	11	" 12	84
66	3	6.3	3.8	" "	3.8	Tuberculous	November 8	29	December 23	47
5	18	6.2	6.4	" "	6.2	O. K.	December 29	15	January 16	73
52	42	6.2	5.2	" "	5.2	...	February 15	3	February 24	63
73	4	6.0	3.6	" "	3.6	Tuberculous	November 16	21	December 23	72
39	23	5.8	4.6	" "	4.6	Suspected	December 29	20	January 12	70
51	40	5.5	4.1	" "	3.7	...	January 2	4	" 16	50
9	14	5.4	4.4	" "	3.4	Suspected	December 29	11	" 20	30
8	19	5.4	5.2	" "	5.2	"	" 29	6	January 16	58
77	15	5.3	4.7	" "	4.1	Doubtful	" 29	9	" 12	45
12	12	5.2	5.2	" "	5.2	Suspected	" 29	14	" 20	59
71	36	5.1	4.5	" "	4.1	O. K.	January 2	26	" 16	43
56	32	5.0	4.2	" "	3.5	"	" 2	16	" 22	34
...	2	4.8	2.2	...	2.2	" "	November 8	2	November 9	27
...	5	4.6	2.8	...	1.6	...	December 11	2	January 15	32
244	21	4.6	4.1	Evidently Tuberculous	4.0	Tuberculous	" 29	7	" 22	28
4	25	4.4	3.8	" "	3.8	Suspected	" 29	16	" 22	38
68	20	4.2	4.0	" "	3.8	O. K.	" 29	7	" 22	8
17	26	4.0	2.3	Probably "	1.6	"	January 2	?	February 8	33
16	28	4.0	2.7	Evidently "	2.7	...	" 2	11	January 20	20
11	16	3.6	5.2	Probably "	3.2	Suspected	December 29	?	February 5	5
75	13	3.4	3.4	" "	2.0	...	" 29	10	" 6	7
1	1	3.3	1.2	...	...	Tuberculous	July 24	48	November 30	8
2	8	3.1	3.1	Probably Tuberculous	3.1	O. K.	December 29	7	February 24	9
6	39	3.0	2.4	" "	2.4	Suspected	January 2	19	January 15	19
53	43	2.7	1.9	Doubtful	1.9	...	February 15	...	...	+1
10	9	2.6	3.4	Possibly Tuberculous	2.0	Suspected	December 29	...	...	+1
14	10	2.6	2.4	Probably O. K.	0.4	O. K.	" 29	...	...	+1
69	11	2.4	4.4	" " "	...	"	" 29	...	...	...

TABLE V.—Continued.

Cases Arranged in Order of Absolute Height, Giving Class, According to Koch Test, Based on Height, Apparent Reaction and Range.

Tag.	Case.	Rise above 100°.	Range.	Diagnosis by the Koch Test.	Rise above Initial Temperature.	Diagnosis by Physical Examination.	Date of Injection.	Amount of Tubercle.	Date of Autopsy.	Total Reaction.
55	24	2.3	3.7	Probably Tuberculous	2.9	O. K.	December 29	8	February 28	4
74	33	2.0	1.3	Apparently O. K.		"	January 2			
54	41	1.9	0.7	Evidently "			" 2			
3	7	1.8	1.8	" "		Suspected	December 29			
63	35	1.8	0.5	" "	0.2	O. K.	January 2			
58	31	1.7	0.6	" "		"	" 2			
59	37	1.7	2.0	" "			" 2			
S	38	1.7	1.7	" "	0.4		" 2			
62	30	1.5	3.5	Probably "		O. K.	" 2			
72	22	1.4	2.0	Evidently "	0.6	"	December 29			
61	29	1.2	1.2	" "		"	January 2			
O	34	1.2	0.6	" "		Suspected	" 2			

EXPLANATION OF TABLE V.

After the perceding tables were prepared in the rough, a chart of emperature curves was plotted (Chart I.), from which, by taking the ıbsolute height of the curves as a basis, the cases were arranged as in Table V., in the order of the maxima, by comparing the rise above he initial temperature, and the entire range of the temperatures for naxima between 102° and 103° (the chart apparently showing that verthing above 103° is tuberculous), I could arrange these doubtful ases in sequence, and characterize them as doubtful, probably, or ossibly tuberculous or O. K., as the case might be. So little has his order been disturbed by introduction of a more accurate method f determining the reaction that the old table has been introduced ıere without change, except slight new choice of words, and that the rder of maxima has given the succession. The killing has been lone in accordance with the column headed "diagnosis by the Koch est," no great effort being made to take up the cows in the order here given, except to keep to the order of the groups, "decidedly," 'evidently" and "probably," tag 6 excepted. (The "possibly" and 'doubtful" [9 and 43] have at this writing not yet been killed.) This narks the limit, so long as cases 16 and 26 remain doubtful in the utopsy. The last column shows they have a very low total reaction. They will, however, receive further study, and may yet pay the enalty.

It will be noticed that I ignored the ordinary method of calculating he reaction, viz., by taking the difference between the initial tempera- ure and the highest later observed temperature. Such a procedure eemed to me to be extremely inaccurate, but careful studies of my lata have shown that this method is not so bad as it at first sight ap- ears. I have, therefore, called it the "approximate reaction." It is asy to see that in some cases it is too great, and in others too small, hus the cases are not treated alike, and it is impossible to grade them n proper order. Fortunately the majority of cases react so markedly hat the margin of inaccuracy is more than swallowed up, so that if he operator chooses a sufficiently high reaction as his limit, he has no lifficulty in showing that the verdict rendered by the injection of Koch's lymph is infallibly justified by the autopsy. Practice seems o have settled on this limit as 2.5° above initial evening temperature, xperience having shown that to take a smaller limit is apt to include

some sound animals which result is of course naturally avoided; but experience has equally shown (our own in particular) that tuberculous animals have given a smaller "approximate reaction," and thus we may be certain that Koch's lymph as ordinarily used fails to stamp out tuberculosis, *root and branch*, from large herds. I believe that evidence sufficient has been accumulated to make any experimenter certain that *every reacting animal has tubercle*, but the trouble lies in determining what is a reaction in certain exceptional instances. Case 1, the most tuberculous of all our herd, gave no approximate reaction, in fact it resembled the healthy cows in giving the uninfluenced maximal temperature at evening; though to be sure this temperature was relatively high, it was no higher than dozens of normal temperatures recorded in tables by other observers, such as those recorded by Dr. Leonard Pearson, for the Pennsylvania State College herd (Bulletin 21); Dr. E. P. Niles, for the Virginia State Station herd (Bulletin 26); and Dr. Conrow, for the Taylor herd, Burlington N. J. (Vet. Mag., Jan., '94). Case 1 was, however, so advanced as to make error of physical diagnosis impossible; but, unfortunately, there is no absolute relation between amount of reaction and amount of tuberculosis; while some "incipient" cases give an extremely high reaction, others give low and doubtful reactions. It is, therefore, worth while to study into this matter closely, to see if a more equable reaction determination be possible.

Now, what causes the "fever reaction"—the rise of temperature? Evidently an increased oxidation, accompanied by increased activity in the tissue cells, due to increased stimulation. How does Koch's lymph secure this result? The subject is practically a mystery. The best answer yet made runs somewhat as follows: The lymph is an extract of tuberculous tissue, and hence, among other matters, contains the toxines which the tubercle bacilli have produced. A small amount of these toxines is readily excreted from the body before they can produce any serious effect on the tissue cells. This explains why a small dose injected into a healthy animal produces no effect. But if the tubercle germs have been for some time at work, they have manufactured an additional amount of toxine (or ptomaine). If this amount is very great, the small amount added by injection increases this amount by so small an increment as to be unnoticed; but when the ptomaine in the tissues is less, the increment is noticeable. According to this explanation, the healthy cow receives the maximal

increment, and so we see a fault in the theory. I would offer this amendment, viz., the presence of the bacilli, and of the poisons they excrete, causes an increased activity of the tissues, both in the work of getting rid of the poison by excretion and in the work of secreting toxalbumens inimical to the germ, and we may also include the work of producing tubercle. This increased work is so little, or is distributed over so long a time, as at no period to seriously influence the general temperature until the disease has reached an extreme point. That is, *there is always a reaction present in a tuberculous animal*, but usually so small as to be unnoticeable. The rate at which the bacilli secrete the toxine is so uniform as not to present any special breaks or accessions that may serve as stimuli, but the injection of a quantity bearing an appreciable relation to that which the tissues are already responding to, is such a sudden increment that the *tissues respond by a sudden increase in the work they are already engaged in.*

The tissues of a sound animal are not adjusted to take any special notice of a slight and temporary accession of poison. It requires the presence of this slight amount for such protracted periods as the bacilli supply, to develop this sensibility of the cells.

It follows that any observed temperature is a resultant of two sets of forces—first, those that produce the *normal* temperature, or the temperature that would be present if the injection lymph were absent; second, the *sensibility* of the tissues to the particular *increment* of stimulus. Both this sensibility and the magnitude of this increment are unknown quantities, and if injection be made, the normal curve of temperature for all the time the lymph is acting is, of course, also unknown. We possess simply the observed temperature, and no one is competent to declare how much of this temperature is "reaction." That is, *the exact amount of reaction in any given case is, on a priori grounds, absolutely unknown now*, and perhaps impossible of knowledge to future science.

We may, however, approximate to this quantity by gaining some idea of the probable normal temperature at the particular time the temperature was taken, *i. e.* what would the temperature have been if injection had not been made?

It becomes first and foremost necessary to study the behavior of temperature curves for normal cases. This work we did not at first realize the importance of, so that the data herewith presented are necessarily less full than is desirable. We may include as "normal tem-

peratures" all those temperatures, of cows under injection, which manifestly have not been disturbed by injection, viz., the initial temperature, and all subsequent observations up to the point where the reaction becomes manifest. As our injection was made on a falling thermometer, such point of reaction is in the majority of instances easily discoverable. There is a latent period after injection, before the lymph produces its effects. As to the law of this latent period we refer to later pages.

Of course, the entire series of observations, for sound cows under injection, becomes available, and also the data collected in Tables III. and IV.

TABLE VI.

Showing Relative Distribution of Normal Temperatures.

Temperatures.	PERIODS:	Period IV.	Period V.	Period VI.	Period VII.	Period VIII.	Period I.	Period II.
	HOURS:	Morning, 5–8.	Forenoon, 8–11.	Noon, 12–2.	Afternoon, 2:30–4:30.	Evening, 5:30–7:30.	Bedtime, 8–10.	Midnight, 12–2.
	MAXIMA:	102 0°	—102.4°	—102.0°	+ 102.2°	102.6°	—102.2°	102.0°
Ultra-high.	102.6°	...	1	1	1	...	...	...
High.	102.4	...	...	...	...	2	...	...
	102.2	...	...	1	...	6	1	...
	102.0	... 11 per cent.	5 27 per cent.	1 13 per cent.	1 11 per cent.	6 29 per cent.	1 25 per cent	... 21 per cent.
	101.8	5	5	...	2	10	7	4
	101.6	2	6	3	2	7	2	3
Middle.	101.4	4	5	3	2	9	5	3
	101.2	7	8	2	7	12	8	2
	101.0	6 45 per cent	9 60 per cent.	1 37 per cent	8 67 per cent.	10 49 per cent.	8 62 per cent.	2 52 per cent.
	100.8	6	7	6	7	8	1	3
	100.6	4	7	2	6	12	4	7
Low.	100.4	6	1	4	2	8	...	1
	100.2	2	2	3	1	5	4	...
	100.0	11 37 per cent.	2 10 per cent.	3 37 per cent.	3 18 per cent.	6 19 per cent	... 11 per cent.	4 15 per cent.
	99.8	3	1	2	2	.....	1	...
	99.6	...	...	2	...	2	...	...
Ultra low.	99.4	1	...	1	...	1	...	...
	99.2	...	...	1	...	.....	1	...
	99.0	1 7 per cent	... 2 per cent	... 13 per cent.	1 2 per cent.	..... 3 per cent	... 2 per cent	... 12 per cent.
	98.8	1	...	...	...	.....	...	1
	98.6	1	1	3	...	.....	...	...
	98.4	...	...	...	...	.....	...	1
	98.2	...	...	...	...	.....	...	...
	98.0	...	...	...	...	2	...	2
	Total cases	60	60	39	45	106	44	34
		Minimum No. 1.	Maximum No 2.	Minimum No. 2.	Middle No. 1.	Maximum No. 1.	Middle No. 2.	Minimum No. 3.

RULE.—Least concentration of temperatures occurs at minimal periods, and *vice versa*.

EXPLANATION OF TABLE VI.

In accordance with the reasoning just presented, these data of normal temperatures were plotted into a table shown in No. VI. The temperatures on each side (above and below) 99° are grouped as "ultra-low," those about 100° as "low," those about 101° as "middle," those about 102° as "high," and those above 102.5° as "ultra-high." Only the even tenths are presented. All readings falling on odd tenths have been shoved up one-tenth of a degree.

Following these temperatures are the figures representing the number of times this reading was presented in each period. The percentage of cases for each group was calculated, and a study of the table shows that neglecting the period from 2:30 A. M. to 5 A. M., called "foredawn," for which we have scarcely any readings, the other periods present three columns in which the temperatures range lowest, two in which they range highest and two connecting, "middle" periods. The highest maximal and the lowest minimal periods are numbered "1" respectively, and fall at evening and at morning respectively. The other maximal period is shortly before noon, which is itself the second minimum (minimum No. 3, coming at midnight). At the top of the columns are the maximal temperatures for normal cases, so that any cow presenting a higher reading at these periods than these maxima, must be considered "suspected." The "minimum" periods are produced by a certain number of cases dropping, some further than others, and the maximal periods by the reverse process, so that viewed from above downwards, the maxima show a much better concentration of the temperatures than do the minima, but all these periods give us a range of four degrees or more within which the temperature of a cow may occur and still be normal.

But this is for the entire herd; no one cow is apt to run the gamut of these four degrees. What may be considered the highest range to be expected of any particular animal? We have data bearing on this point, but unfortunately the number of observations are less extensive than should be required, and future work along this line has been planned. We may, however, present what facts we have as follows:

TABLE VII.

Showing Highest Variation in Temperature of Same Animal in Each Period.

	Number of Case.	Morning.	Forenoon.	Noon.	Afternoon.	Evening.
Calculation of the vari-ion of single animal in ening temperatures, for ccessive evenings, for irty cases, gave the aximum variation as 2°.	8	0.6	1.2	1.8	1.8	1.4
	9	0.3	0.7	0.7	1.4	0.8
	10	0.6	0.7	0.9	0.1	0.8
	11	0.2	1.0	0.6	0.3	0.1
	13	0.8	0.9	0.4	0.8	0.4
	16	1.6	1.4	0.6	0.8	22 (30)
	20	2.1	0.3	....	0.1	0.1
	21	0.0	0.3	....	1.2	1.0
	25	0.1	0.3	....	0.2	0.6
	26	0.0	1.2	0.9	0.2	0.7
	28	0.6	0.2	....	0.2	2.2
	36	0.0	0.2	....	0.3	0.7
	Maxima:	2.1	1.4	1.8	1.8	2.2 (?)

From Table VII. we may conclude that the greatest departure any imal is likely to show from any observed temperature of any day, any preceding or succeeding day, at the same hour, is in the neighrhood of two degrees for the morning and evening, and less than o degrees during the day. This must guide us in any comparison may make between a supposed reaction temperature of any period d a known normal temperature for same period twenty-four hours moved therefrom.

TABLE VIII.

Normal Temperatures of Critical Periods, Associated with Evening Temperatures, in a Herd.

Groups.	Evening Temperatures.	Morning Temperatures. Period IV.	Forenoon Temperatures. Period V.	Noon Temperatures. Period VI.
Low.	102.6			
	102.4	98.6	1.4 1.0 0.8 0.4	1.6 1.4
	102.2	1.8 1.2	$\frac{2}{2.0}$	0.2 98.6
	102.0	1.8 $\frac{2}{1.4}$ 1.2 0.2	2.0 $\frac{2}{1.8}$ 1.6 0.8	2.6 100
	101.8	$\frac{2}{1.8}$ 1.6 1.4 1.2 0.8 100	2.6 $\frac{2}{2.0}$ 1.8 1.4	1.2 $\frac{2}{0.8}$ 0.2
	101.6	$\frac{2}{1.4}$ 0.4 100	1.6 1.2 $\frac{2}{0.4}$	0.4
Middle.	101.4	$\frac{2}{2.4}$ $\frac{2}{1.2}$	2.6 1.8 $\frac{3}{1.6}$ 1.0	0.8 100 98.6
	101.2	$\frac{2}{1.4}$ $\frac{5}{1.2}$ $\frac{2}{0.8}$ 0.4	2.0 $\frac{2}{1.6}$ $\frac{2}{1.4}$ 1.2 $\frac{2}{1.0}$ 0.8 0.6	$\frac{2}{1.6}$ 1.4 98.6
	101.0	1.2 $\frac{2}{0.6}$ 0.4 $\frac{3}{100}$	1.2 $\frac{4}{0.8}$ 0.6	1.0 0.8 0.4 100
	100.8	$\frac{2}{1.0}$ 0.8 100 $\frac{2}{9.9}$ 98	1.4 $\frac{3}{1.2}$ 1.0 0.8 100	1.6 1.4 0.8 0.6 99.8 99.4 99.2
	100.6	$\frac{3}{1.0}$ $\frac{2}{0.8}$ 0.6 0.4 $\frac{2}{100}$	1.8 1.4 $\frac{2}{1.2}$ $\frac{2}{1.0}$ 0.8 0.6	1.4 $\frac{2}{0.8}$ 0.6 99.4

TABLE VIII.—Continued.

Normal Temperatures of Critical Periods, Associated with Evening Temperatures, in a Herd.

Groups.	Evening Temperatures.	Morning Temperatures. Period IV.	Forenoon Temperatures. Period V.	Noon Temperatures. Period VI.
High.	100.4	0.8 0.4 0.2	1.4 $\frac{3}{1.0}$ 0.6	1.2 0.8 0.2 99.6
	100.2	$\frac{2}{100}$	1.0 0.2	0.4
	100.0	1.0 0.8 99.8 99.	1.4 1.0 0.6	1.4 0.4 0.2
	99.8 99.6	0.4 99.8	1.4 98.6	99.6 98.6
Ultra-Low.	98.0	0.6 99.6	0.8 0.6	9.8

N. B.—The numerators indicate number of instances of particular association given by denominator.

TABLE IX.

Showing the Maximal Departure from Initial Evening Temperature, of Temperatures of Critical Periods.

Evening Temperatures.	Period IV. Morning.		Period V. Forenoon.		Period VI. Noon.		Period VIII. Evening.	
	Rise.	Fall.	Rise.	Fall.	Rise.	Fall.	Rise.	Fall.
102.6°	....	....	....	....	....	....	....	2.2°
102.4	....	(3.8°)	....	2.0°	....	1.0°	....	1.6
102.2	....	1.0	....	0.2	....	2.0 (4.6)	....	1.0
102.0	....	1.8	....	1.2	0.6°	1.6	....	1.4
101.8	....	1.8	0.8°	0.4	....	1.2	0.4°	1.7
101.6	....	1.6	....	1.2	....	1.4 (2.8) ?	0.7	0.9
101.4	1.0°	0.2	1.2	0.4	....	2.6	0.5	0.6
101.2	0.2	.8	0.8	0.6	0.4	1.0	0.9	0.7
101.0	0.2	1.0	0.2	0.4	....	1.6	0.8	1.6
100.8	0.2	1.0	0.6	0.8	0.8	1.2	1.6	0.5
100.6	0.4	0.6	1.2	....	0.8	0.8	1.4	0.6
100.4	0.4	0.2	1.0	....	0.8	....	0.6	0.9
100.2	....	0.2	1.4	....	0.2	....	1.6	2.2
100.0	1.0	1.0	....	....	1.4	....	1.7	....
99.8	....	....	....	....	....	....	....	....
99.6	0.8	....	1.8	1.0	....	1.0	0.8	....
99.4	....	....	....	....	....	....	1.6	....
98.0	2.6	....	2.8	....	....	....	2.2	....
Maxima.....	—2.6	+18	—2.8	—2.0	1.4	2.8?	—2.2	2.2
Laws for occurrence of maxima and minima of normal temperatures calculated from the initial evening temperature.	Above 101° (initial) the normal coincides; below this temperature, count from 101°.	Runs below 100 6° in proportion as initial exceeds 100.6°.	Below 102° (initial) runs a degree above initial, but does not exceed 102.4°.	Averages a degree below initial temperature.	Approximately occurs at 101.6°.	Runs 1.5° below initial.	Runs 1.5 above initial temperature, but does not exceed 102.6°.	Averages 1.5° below initial temperature.
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.

Suppose, however, we have but one series of observations for les than a twenty-four-hour period. What departure from any initia temperature may be expected in any subsequent period? Our dat must be judged from the initial evening temperatures. Table VIII shows the temperatures for the critical periods (when reaction i measured) that were associated in the same animal with the evenin temperatures shown in the first column. From this table and othe data we have prepared Table IX., which shows the greatest amour of departure from the initial temperatures which the various case presented, both in an upward and downward direction. From thi

table we see that we have departures from the initial temperature ranging from 1.4° to 2.8° (neglecting one or two very aberrant cases). The general average of these departures is about 2.5°, which has already been independently chosen by operators as the limit of legitimate variation from the initial temperature. An examination of these tables shows further that the general tendency of these associations is to keep within still narrower limits of the initial temperature, so that a degree, or at most two degrees, limit of variation is more nearly approximately the true normal departure. Thus we have now seen the strongest evidence that can be offered in favor of using this method for "approximate" determination of the reaction.

When, however, the initial temperatures are relatively high, it is manifestly wrong to allow any margin in an upward direction. Our data show that in such cases the subsequent temperatures are correspondingly lower than they would be if the initial temperatures were low, and the reverse rule also holds good. *Thus it follows that we can use, with equal certainty, a fixed standard of reference,* and this was employed in Table V. with marked success. After finding how much the initial temperature was a guide to the subsequent normal, I concluded to calculate the reaction from rules discoverable by inspection of Table IX. *These rules* combine the advantages of both methods in such a way as to eliminate some of the factors of error present in each. The rules are in place on Table IX., and need not be repeated here. It will be noticed, however, that there is some variation in the rules for the different periods. The difference between the maximal normal, as calculated by these rules, and the actual record may be termed the "supra-maximal excess," or simply "maximal excess," it being understood that no reaction is to be predicated if the recorded temperature falls below the calculated normal. As this maximum is based on data from all the herd, and up to which only a few animals come, there is left a wide zone in which individual cases of normal temperature may occur, clear down to the minimal normals of a herd. That is, the maximal excess is the "least actual reaction," while it is possible that the real reaction may also include this wide zone (greatest downward departure to greatest upward departure). When so included, we have the "possible excess." To determine the probable location of the real reaction between these limits, it is necessary to observe the individual cow for a protracted period, in order to learn the most usual associations with the initial temperature, or to deter-

mine the usual habit of variation at the hours the reaction occurred. Such a calculation will give the "mean reaction," which, of course, is only the nearest approximation which it is possible for us to make. Unnecessary as it is in the majority of cases to go to all this trouble, *it is necessary, if we wish to determine all the cases of reaction.* Let the reader emphasize this point. We see just what care must be exercised if we would reduce the present element of uncertainty which all operators realize exists, and which has been well expressed by Dr. Pearson as follows (italics his):

"*But we have not yet reached the time when it will be possible to give each animal in a herd the same dose of tuberculin, measure the temperature and blindly declare each animal which reacts, tuberculous and the others healthy.*"

So far as our experience goes, the above quotation may be revised to read:

"We have not yet sufficient knowledge of the true normal temperature which we may expect of any particular cow so that we can declare what, if any, the reaction in her case is."

I think, however, that we can attain a closer approximation to this knowledge by proceeding according to the rules laid down in this paper.

TABLE X.

Giving a Comparison Between the Least and the Possible Reactions, as Calculated by General Rules and from Individual Records.

Case.	Dates.	Night and Initial Evening Temperatures.	Morning.	Forenoon.	Noon.	Afternoon.	Evening.
16	December 29	100.4 101.6 98.4	100.4	101.2	103.6	102.0	103.4
	January 9		99.5	100.6	99.8	100.6	98.0
	" 10	Approx. react.,	100.0	100.2	......	100.0	100.2
	" 23	3.2	99 0	101.3	100.4	100.5	100.0
	" 24		100.6	99.9	99.9	100.8	101.0
	Individual { Least excess				3.2	1.2	2.4
	Individual { Possible excess				3.8	2.0	5.4
	Individual { Mean excess				3.6	1.5	3.4
	General { Least excess				2.0	......	1.5
	General { Possible excess				4.2	......	......
9	December 29	100.6 99.2 100.0	101.0	101.0	101.4	102 6	100.0
	January 23	Approx. react., 2.0	100.7	100.5	100.2	100.5	100.4
	" 24		100.9	101.2	100.7	101.0	100.8
	March 20	100.2 100.6	100.9	101.0	......	101.9	100.4
	Individual { Least excess					0 7	......
	Individual { Possible excess					2.1	......
	Individual { Mean excess					1.5	......
	General { Least excess					0.4	......
8	December 29	100.0 100 8 100.0	100.8	102.6	103.1	102.4	101.7
	January 23	Approx. react.,	100.7	100.6	100.7	100.7	100.6
	" 24	3.1	100.2	101.8	102.5	102.5	102.0
	Individual { Least excess			0.8	0.6	......	......
	Individual { Possible excess			2.0	2.4	......	......
	Individual { Mean excess			1.4	1.5	......	......
	General { Least excess			1.6	1.5	0.2	......
	General { Possible excess			3.6	3.1	......	......
10	December 29	102.2 101.4 101.2	101.8	102.0	100.2	102.6	101.8
	January 23	Ap. react., .04	101.2	101.2	101.0	101.2	101.0
	" 24		101.6	101.9	101.1	101.3	101.8
	Individual { Least excess (nearly mean and possible)					1.3	......
	General { Least excess					0.4	......
11	December 29	102.4 100.6 98.0	99.8	101.0	99.6	100.0	100.8
	January 23		99.9	100.0	99.1	99.9	100.8
	" 24		100.0	100.7	99.7	100.2	100.7
13	December 29	101.4 100.2 100.0	100 8	101.6	102.7	103.4	101.8
	January 23	Ap. react., 2.0	100.4	100.7	100.4	101.0	101.0
	" 24		100.0	101.0	100.0	100.2	101.4
	Individual { Least excess			0.6	2.3	2.4	0.4
	Individual { Possible excess			0.9	2.7	3.2	0.8
	General { Least excess				1.1	1.2	......
	General { Possible excess				3.3	......	......

TABLE X.—Continued.

Giving a Comparison Between the Least and the Possible Reactions, as Calculated by General Rules and from Individual Records.

Case.	Dates.	Night and Initial Evening Temperature.	Morning.	Forenoon.	Noon.	Afternoon.	Evening.
20	December 29	100.4 100.2 101.0	101.6	104.2	101.4	100.4	100.2
	January 9	Ap. react., 2.8	98.9	101.2	100.5	100.6	100.7
	" 10		101.0	100.9	....	100.7	100.6
	Individual	Least excess	....	3.0	....	....	....
		Possible excess	2.7	3.3	....	....	....
	General	Least excess	....	2.8	....	....	....
		Possible excess	....	3.8	1.8	....	....
21	December 29	100.6 101.0 102.4	104.6	104.1	102.5	101.2	101.5
	January 9	Ap. react., 4.0	100.4	101.4	101.3	100.9	101.1
	" 10		100.4	101.1	....	100.0	100.5
	Individual	Least excess 1.4	4.2	2 7	1.2	....	....
	General	Least excess	3.6	2.5	0.9	....	....
		Possible excess	....	4.5	3.0	....	....
25	December 29	100.6 100.6 100 6	102.4	104.0	104.3	104.4	103.4
	January 9	Ap. react., 3.8	100.1	101.0	101.2	100.8	100.3
	" 10		100.0	100.7	....	100.6	100.9
	Individual	Least excess	2.3	3.0	3.1	3.6	2.3
	General	Least excess	1.4	2.4	2.7	2.2	1.3
		Possible excess	1.8	4.4	4.7	....	....
26	January 2	102.2 102.4 104.0	102.0	101.5	....	103.8	101.8
	" 23	Ap. react., 1.8	100.4	100.3	100.4	101.7	101.6
	" 24		100.4	101.4	101.5	101.9	102.3
	Individual	Least excess 1.6	1.6	0.1	....	1.9	....
		Possible excess	....	1.2	....	....	....
	General	Least excess 2.2	....	....	....	1.6	....
		Possible excess	3.6	0.3	....	....	....
28	January 2	101.3 101.8 101.8	103.5	104.0	....	104.0	101.8
	" 9	Ap. react., 2.7	100.0	101.0	100.4	100.9	100.2
	" 10		100.6	100.8	....	100.7	98.0
	Individual	Least excess	2.9	3.0	....	3.1	....
		Possible excess	3.5	....	....	....	3.8
	General	Least excess	1.2	1.7	....	1.8	....
		Possible excess	2.6	3.7	....	....	....
30	January 2	101.5 101.0 98.0	100.0	100.4	....	101.0	101.0
	" 23		100.5	100.8	100.5	101.2	100.6
	" 24		100 5	100.8	100.7	101.0	101.0
36	January 2	101.0 101.6 100.6	103.6	105.1	....	103 5	103.7
	" 9	Ap. react., 4.1	100.0	100.9	100.8	100.8	100.3
	" 10		100.0	100.7	....	100.5	101.0
	Individual	Least excess	3.6	4 2	....	2.7	2.7
	General	Least excess	2.6	3.1	....	1.3	1.7
		Possible excess	3.2	5.1	....	....	....

Not any of our cases have been observed long enough to determine the probable reaction. The few records we have on this line we present in Table X., an inspection of which table serves to show how great the difference is in the application of these various methods. The "approximate reaction" compared with these figures shows how, at one time, the coincidence is with the "least excess;" at another, how it falls in with the greatest "possible excess."

However, the best that can be done is to take the "general rules" and to determine the maximal excess, if any, for each period. Of that much reaction we are at least sure, and we are also sure that the figures more equably represent the true state of things than if we had used the approximate reaction. Accordingly we have Table XI.

TABLE XI.

Showing Excess of Temperatures for the Different Periods; and Comparison of Total Tuberculosis with Total Reaction.

Case.	Evening.	Bedtime.	Midnight.	Foredawn.	Morning.	Forenoon.	Noon.	Afternoon.	Evening.	Maximum.	Time to Maximum.	Time of Maximum.	Duration.	Average Excess.	Total Reaction.	Total Tuberculosis.
											hrs.		hrs.			
1	0.8	0.9	1.4	0.2	0.2	....	....	....	....	1.4	6	8 p. m.	12	0.7	8	48
2	....	0.6	....	1.2	1.2	1.6	3.2	1.4	....	3.2	18	12 m.	18	1.5	27	2
3	....	1.2	....	4.3	4.3	3.4	1.4	1.1	....	4.3	+9	5 a. m.	18	2.6	47	29
4	....	1.2	....	3.0	2.4	3.4	4.4	2.8	3.8	4.4	18	12 m.	24	3.0	72	21
5	0.4	....	....	2.2	2.6	1.6	2.4	1.4	....	2.6	12	5 a. m.	18	1.8	32	2
8	....	....	....	....	....	1 6	1.5	0.2	....	1.6	18	9 a. m.	9	1.1	9	7
9	....	....	....	....	....	....	....	0.4	....	0.4	21	4 p. m.	3	0.4	+1	....
10	....	....	....	....	....	....	....	0.4	....	0.4	21	4 p. m.	3	0.4	+1	....
12	....	....	....	....	3.6	3.6	3.6	3.0	2.7	3.6	12	6 a. m.	18	3.3	59	14
13	....	....	....	....	....	....	1.1	1.2	....	1.2	21	4 p. m.	6	1.2	7	10
14	....	....	....	....	3.4	2.3	2.1	....	....	3.4	12	6 a. m.	12	2.5	30	11
15	....	....	....	....	2.4	3.0	3.7	1.8	1.1	3.7	18	1 p. m.	18	2.5	45	9
16	....	....	....	....	....	....	2.0	....	1.5	2.0	18	1 p. m.	3	1.7	5	?
17	....	....	....	....	5.5	4.8	3.9	2 8	3.5	5.5	12	6 a. m.	+21	4.0	84	11
18	....	....	....	....	2.2	3.9	3.4	4.0	4.5	4.0	18	5 p. m.	21	3.5	73	15
19	....	....	....	....	3.3	3.6	3.0	3.2	1.8	3.6	15	10 a. m.	18	3.0	58	6
20	....	....	....	....	....	2.8	....	....	....	2.8	15	10 a. m.	3	2.8	8	7
21	....	....	0.6	....	3.6	2.5	0.9	....	....	3.6	12	6 a. m.	15	1.9	28	7
23	....	....	....	....	4.0	3.6	4.0	2.6	0.8	4.0	12	6 a. m.	18	3.9	70	20
24	....	....	....	....	....	....	0.7	....	....	0.7	18	2 p. m.	6	0.7	4	8
25	....	....	....	....	1.4	2.4	2.7	2.2	1.3	2.7	18	2 p. m.	18	2.1	38	16
26	....	0.2	2.2	....	....	....	....	1.6	....	2.2	6	12:30 a. m.	+6	1.9	33	1
27	....	....	1.2	....	3.2	3.7	....	4.6	2.5	4.6	18	2:30 p. m.	21	3.1	65	7
28	....	....	....	....	1.2	1.7	....	1.8	....	1.8	18	2:30 p. m.	12	1.6	20	11
32	....	....	....	....	....	2.5	....	2.3	1.3	2.5	15	11 a. m.	15	2.2	34	16
36	....	....	....	....	2.6	3.1	....	1.3	1.7	3.1	12	11 a. m.	18	2.4	43	26
39	....	....	....	....	1.8	1.4	....	....	....	1.8	12	6 a. m.	9	1.6	14	19
40	....	....	....	....	3.7	3.1	....	2.8	1.6	3.7	12	6 a. m.	18	2.8	50	4
42	....	....	....	1.6	4.0	3.5	....	....	....	4.0	10	8:30 p. m.	21	?	63	3
43	....	....	....	....	0.5	....	....	....	....	0.5	10	8:30 p. m.	3	?	+1	....

EXPLANATION OF TABLE XI.

This table was calculated by the methods just discussed; for bedtime period we added a degree to the initial to get the normal, not to exceed 102.2°; for midnight we chose the maximum 101.8° as a fixed normal; for afternoon the fixed normal maximum of 102.2° was chosen.

The first thing that strikes us is that by these rules the period having the highest temperature need not be the one necessarily which gives the highest reaction. Thus we discover that No. 1, which had a continuously falling temperature, shows a decided reaction at midnight. We also learn that the reaction period is one of varying length, and that the highest point in it, is not necessarily at its middle, although there seems to be a general tendency towards a regular curve, whose height increases with the length, but not directly so, the longer curves being much flatter than the shorter ones. In calculating the "duration of a reaction," we have been guided largely by the general nature of the few curves that are complete, as most of the longer ones have both ends disappearing in periods where no observation was taken. Thus the figures on this head are probably rather roughly approximate. The total reaction was calculated by multiplying the average reaction into the "duration."

TABLE XII.

Showing Duration of Reactions, and Height and Location of Their Maximal Points.

Number of Case.	Evening. I.	Bedtime. II.	Midnight. III.	Foredawn. IV.	Morning. V.	Forenoon. VI.	Noon. VII.	Afternoon. VIII.	Evening.	Amount of Tuberculosis.	Time from Injection to Maximum.
1			1.4							48	6
2							3.2			2	18
3	3			4.3						29	+9
4	4						4.4			21	18
5			5		2.6					2	12
8			8			1.6				7	18
9			9					.4		?	18
10			10					.4		?	18
12			12		3.6					14	12
13			13				1.2			10	21
14			14		3.4					11	12
15			15			3.7				9	18
16			16			2.0				?	18
17			17		5.5					11	12
18			18			4.0				15	18
19			19			3.6				6	15
20			20			2.8				7	15
21		21			3.6					7	12
23		23			4.0	4.0				20	12
24		24					.7			8	18
25		25				2.7				16	18
26	2.6		2.2				1.6			1	6+21
27	2.7					4.6				7	18
28				28		1.8				11	18
32				32		2.5	2.5			16	15
36				36	3.1					26	12
39				39	1.8					16	12
40				40	3.7					4	12

CRITICAL PERIODS.

N. B.—Dotted lines show supposed presence of reaction, and the absence of observation.
RULE.—The greater the tuberculosis, the earlier the reaction and maximum.

EXPLANATION OF TABLE XII.

This table is partly also a chart showing by means of lines the ength of the reactions, the height of the highest reaction, and the oint in the line where this maximum occurs. The main object of he chart is to show that observation at morning, forenoon and noon trikes most (though not all) the reactions at some point where reaction an be determined. These periods are, therefore, the most "critical" n importance; but the midnight and afternoon periods are needed to nclude *all* the cases, while if one desires to get a proper idea of the duration" from which to calculate the total reaction, it becomes needul to observe, not only in all the periods of the first night and day, ut indefinitely into the second night. For practical purposes this is ot needful, as the long reactions are easily diagnosed from a single bservation, which is likely to strike them anywhere. It is the short eactions that may escape us; these, as can be seen, occur late in the ay. Thus in selecting cows for purchase, if on being tested for welve or fifteen hours, and no reaction occurs, it is not safe to stop at his point, because a reaction may be found at eighteen or twenty-one ours after injection.

TABLE XIII.

Showing the Co-Variants of H. M. E.

Highest Maximal Excess.	Time from Initial Temperature to Beginning of Reaction.	Duration of Reaction.	Maximal Temperature.	O'clock of M. T.	Total Reaction.	Rise from Initial Temperature.	Amount of Tubercle.	Number of Case.
5.5	6 hrs.	+21 hrs.	106.5	6 a. m.	84	6.3	11	17
4.6	3	21	106.8	2 p. m.	65	4.7	7	27
4.4	3	24	106.0	12 m.	72	3.6	21	4
4.3	3	18	106.3	5 a. m.	47	3.8	29	3
4.0	6	21	106.2	4 p. m.	69	6.2	15	18
4.0	6	18	105.8	10 a. m.	70	4.6	20	23
4.0	6	21	106.2	8 p. m.	63	5.2	3	42
3.7	+6	18	105.3	12 m.	45	4.1	9	15
3.7	6	18	105.5	6 a. m.	50	3.7	4	40
3.6	6	18	105.2	1 p. m.	59	5.2	14	12
3.6	6	18	105.4	5 p. m.	58	5.2	6	19
3.6	+3	15	104.6	6 a. m.	28	4.0	7	21
3.4	6	12	105.4	6 a. m.	30	3.4	11	14
3.2	3	18	104.8	12 m.	27	2.2	2	2
2.8	12	3	104.2	10 a. m.	8	3.8	7	20
2.7	9	18	104.4	5 p. m.	38	3.8	16	25
2.6	—6	18	104.6	5 a. m.	32	1.6	2	5
2.6	+6	18	105.1	11 a. m.	43	4.1	26	36
2.5	12	15	105.0	11 a. m.	34	3.5	16	32
2.2	3	+6	104.0	12 a. m.	33	1.6	1	26
2.0	15	3	103.6	1 p. m.	5	3.2	?	16
1.8	9	12	104.0	11 a. m.	20	2.7	11	28
1.8	9	9	103.0	11 a. m.	14	2.4	19	39
1.6	12	9	103.1	1 p. m.	9	3.1	7	8
1.4	0	12	+103.3	8 p. m.	8	....	48	1
1.2	15	6	103.4	4 p. m.	7	2.0	10	13
.7	15	6	102.3	2 p. m.	4	2.9	8	24
.5	6	3	102.7	8 p. m.	+1	1.9	....	43
.4	18	3	102.6	4 p. m.	+1	2.0	....	9
.4	18	3	102.6	4 p. m.	+1	4.0	....	10

A STUDY OF CO-VARIANTS AND DI-VARIANTS.

We have now, from direct observation and from calculation, quite a number of facts pertaining to each case, and it behooves us to compare these facts to see how they are related.

DISCUSSION OF TABLE XIII.

This table has the highest maximal excess figures placed in the order of their magnitude, beginning with the highest. In succeeding columns are placed the facts that are associated with each "H. M. E. number," and from a diligent study of them the following laws appear:

(1) The higher the reaction the sooner it occurs. Should this law be definitely established, it would show that the calculated reaction for No. 1 gives a greatly too low figure.

(2) The higher the reaction the longer it lasts. Should this law be shown to be absolute, we have but to determine the duration of a reaction to enable us to judge of its probable height.

(3) Naturally, the maximal temperature will directly co-vary with the H. M. E.

(4) Naturally, also, it follows from (1) that the o'clock of the occurrence of the maximal temperature is later in the day, the smaller the H. M. E.

(5) Naturally, the total reaction will vary, but not uniformly, with the H. M. E. If we had a true record of maximal excesses and of "durations," I believe that the "total reaction," as calculated from their product, would be a valuable set of data from a purely physiological standpoint, for this alone would really express the "true reaction."

(6) The next column gives the "approximate reaction," and shows how far this varies from the order of the H. M. E., although a general co-variation is naturally to be expected.

(7) The amount of tuberculosis seems to be thoroughly disvariant with H. M. E., and about everything else in the table. This shows that the reaction is in no wise directly dependent on the amount of tuberculosis. Sometimes the high reaction indicates a small amount, and in other cases a large amount of disease, and *vice versa* for low reactions. What is to be ascertained is the *presence of a reaction.* Let no one think that he may allow a few cows to go scot free, as "probably not much affected," because the reaction was "low or doubtful." Herein lies the real reason for emphasizing work of this sort. Let us have all the light we can; let the observations be extended; let the slaughter be extensive until sound animals are sacrificed; let the facts be carefully and fully observed, and with great detail and accuracy, and above all, *let them be published.* Are we to be treated to the spectacle of men going about injecting herds of cattle, making a few temperature observations, killing the cases most obviously reacting, finding, naturally, that their diagnoses were correct, and then pocketing their data, no one knows what they may be? The scientific world gets only the brief mention, "such and such a herd was injected, so many animals were diagnosed as tuberculous, and have been

slaughtered, the diagnosis confirmed, and the carcasses have been buried." *Will any one dare believe that tuberculosis has been stamped out of these herds?* And yet that is what the public are led to think.

TABLE XIV.

Showing Co-variants of Age.

Breed.	AGE.	Highest Maximal Excess.	Total Reaction.	Amount of Tubercle.	Initial Temperature.	Source.	Locality.	Range.	Number of Case.
A.	13 years	1.6	9	7	100.0	J. O. M.	N. J.	3.1	8
S. H.	12 years	3.6	59	14	100 0	S. S.	N. Y.	5.2	12
H.	12 years	1.2	7	10	101.4	M P.	N. J.	3.4	13
H.	10 years	4.3	44	29	102.5	G. W. T.	N. B.	3.8	3
S. H.	10 years	2.0	5	?	100.4	S S.	N. Y.	5.2	16
N.	10 years	2.6	43	26	101.0	D. H. V.	N. B.	4.5	36
G.	10 years	1.8	14	19	100.6	L. P. M.	N. Y.	2.4	39
H.	9 years	1.4	8	48	103 3	M. P.	N. J.	1.2	1
H.	9 years	3.4	30	11	102.0	T. C.	N. B.	4.4	14
J.	9 years	4.0	69	15	100.0	J. O. C.	Conn.	6.4	18
H.	9 years	3.6	28	7	100.6	J. N.	N. B.	4.0	21
H.	9 years	4.0	70	20	101.2	G. W. T.	N. B.	4.6	23
J.	9 years	2.7	38	16	100.6	A. H C.	N. Y.	3 8	25
N.	8 years	2.8	8	7	100.4	P. D.	N. B.	4.0	20
H.	7 years	0.4	+1	....	100.6	G. W. T.	N. B.	3 4	9
A.	7 years	3.7	45	9	101.2	L. S. D.	Vt	4.7	15
N.	7 years	0.7	4	8	109 4	D. H. V.	N. B.	3.7	24
S. H.	6 years	5.5	84	11	100 2	S. S.	N. Y.	6.3	17
G	6 years	3.6	58	6	100.2	W. A. R.	Mass.	5.2	19
G. H.	6 years	2.5	34	16	101 5	G. W. T.	N. B.	4.2	32
H.	2 years 6 months	0.4	+1	....	102.2	Bred.	N. B.	2 7	10
S. H.	2 years 4 months	2.2	33	1	102.2	Bred.	N. B.	2.3	26
S. H.	2 years	4.4	72	21	102.4	Bred.	N. B.	3.6	4
H.	2 years	4.6	65	7	102.1	Bred.	N. B.	4.8	27
J.	1 year 8 months	1 8	20	11	101.3	Bred.	N. B.	2.7	28
G. A.	9 months	3.7	50	4	101.8	Bred.	N. B.	4.1	40
G.	9 months	4.0	63	3	101.0	Bred.	N. B.	5.2	42
G.	9 months	0 5	+1	....	100.8	Bred.	N. B.	1.9	43
J. H.	2 months	2 6	32	2	103.0	Bred.	N. B.	2.8	5
J. H.	1 month	3 2	27	2	102.6	Bred.	N. B.	2.2	2

STUDY OF TABLE XIV.

This table exhibits the co-variants of the age of the animals. We see first that the different breeds are pretty uniformly represented for the different ages. The highest maximal excess seems also to be distributed without reference to age. The total reaction preponderates in amount with the younger animals. *They* have a greater power to react. They also have a less amount of tubercle, and this of itself may explain why the reaction is higher; for, while from Table XIII. we saw that the amount of tubercle did not vary *per individual* with the reaction, on summing up the amount for a number of cases, we

get indications that a small amount of tuberculosis produces a greater total reaction (not necessarily a greater "approximate reaction" or even H. M. E.) than does a more advanced state of the disease. Cows over nine years old have three times as much tuberculosis as those under three years of age. The initial temperature also seems to be higher with young animals, averaging about 102° for those under three years and 101° for those above nine years. This fact is easily observed. Almost any temperature chart where the young animals are exhibited by themselves shows this, and, coupled with the fact that they are less tuberculous, no wonder veterinarians are cautious in diagnosing reaction. But age is one factor to be considered in such a judgment.

The next column of this table shows that the older animals have come from other herds, while all the youngest (below three years of age) have been bred on the farm. The column giving locality shows that not only this State but New York and several of the New England States had their representatives in the herd—all tuberculous. Are we to judge that these States are also saturated with tuberculosis?

TABLE XV.

Showing Variations of Amount of Tubercle with other Co-Variants and Di-Variants.

How Long on Farm.	Breed.	Amount of Tubercle.	Age.	Number of Case.	Breed.	Age.	Amount of Tubercle.	Number of Case.	Physical Examination.	Total Tuberc.	Lung Tuberc.	Number of Case.
3 years	Native	8	7 years	24	Holstein	9	48	1	Tuberculous	48	24	1
2 years 10 mos	Grade Holstein	16	6 years	32	Holstein	10	29	3	Tuberculous	29	16	3
2 years 9 mos	Holstein	10	12 years	13	Holstein	7	......	9	Tuberculous	21	9	4
2 years 9 mos	Holstein	7	9 years	21	Holstein	2½	......	10	Very suspicious	6	3	19
2 years 9 mos	Holstein	20	9 years	23	Holstein	12	10	13	Very suspicious	7	4	21
2 years 8 mos	Holstein	......	7 years	9	Holstein	9	11	14	Suspicious.+	11	4	17
2 years 6 mos	Holstein	......	2 years 6 mos	10	Holstein	9	7	21	Suspicious	......	......	9
2 years 6 mos	Jersey	16	9 years	25	Holstein	9	20	23	Suspicious	?	?	16
2 years 4 mos	Shorthorn	1	2 years 4 mos	26	Holstein	2	7	27	Cough	14	0	12
2 years 4 mos	Holstein	48	9 years	1	Shorthorn	2	21	4	Bronchitis	20	9	23
2 years 4 mos	Holstein	29	10 years	3	Shorthorn	12	14	12	Slightly suspicious	11	5	14
2 years 3 mos	Shorthorn	?	10 years	16	Shorthorn	10	?	16	Slightly suspicious	16	5	25
2 years 2 mos	Ayrshire	9	7 years	15	Shorthorn	6	11	17	Doubtful	9	0	15
2 years 2 mos	Shorthorn	14	12 years	12	Shorthorn	2⅓	1	26	Doubtful	19	6	39
2 years	Shorthorn	21	2 years	4	Guernsey	6	6	19	Doubtful	......	......	43
2 years	Ayrshire	7	13 years	8	Guernsey	10	19	39	No report	10	7	13
2 years	Jersey	15	9 years	18	Guernsey	¾	3	42	No report	1	0	26
2 years	Guernsey	6	6 years	19	Guernsey	¾	......	43	No report	11	1	28
2 years	Holstein	7	2 years	27	Jersey	9	15	18	No report	4	3	40
2 years	Guernsey	19	10 years	39	Jersey	9	16	25	No report	3	2	42
1 year 8 mos	Jersey	11	1 year 8 mos	28	Jersey	1⅔	11	28	No report	2	......	2
1 year 3 mos	Shorthorn	11	6 years	17	Ayrshire	13	7	8	O. K.	2	......	5
1 year 3 mos	Native	26	10 years	36	Ayrshire	7	9	15	O. K.	7	?	8
1 year 2 mos	Holstein	11	9 years	14	Jersey Holstein	1/12	2	2	O. K.	......	......	10
9 mos	Ayrshire	4	9 mos	40	Jersey Holstein	⅙	2	5	O. K.	15	1	18
9 mos	Guernsey	3	9 mos	42	Grade Holstein	6	16	32	O. K.	7	0	20
9 mos	Guernsey	......	9 mos	43	Grade Ayrshire	¾	4	40	O. K.	8	2	24
8 mos	Native	7	8 years	20	Native	8	7	20	O. K.	7	0	27
2 mos	Jersey Holstein	2	2 mos	5	Native	7	8	24	O. K.	16	4	32
1 month	Jersey Holstein	2	1 month	2	Native	10	26	36	O. K.	26	13	36

STUDY OF TABLE XV.

First let us ascertain if the length of time the cows have been members of our herd has influenced the amount of tuberculosis.

Cows over two years at the farm, average in tubercle, 19; in age, 8.

Cows two years at the farm, average in tubercle, 12; in age, 7.

Cows under two years at the farm, average in tubercle, 10; in age, 3.

The age relations show that the tubercle relations should increase no faster than they seem to have done, so that we may conclude that these cattle were infected before coming here.

With reference to the breeds, it is apparent that no one breed has any advantage over the others except the natives. Of course, age must also be taken into consideration. It will be noticed that all the cows added to the herd after being first tested are natives.

The physical examination compared with the amount of tubercle shows, of course, no co-variation. We should expect, however, that the amount of lung tuberculosis would co-vary with the physical diagnosis, and, to a certain extent, this is true. But some individuals remarkably free from lung lesions were "suspected," while others pronounced O. K. had a very high state of lung tuberculosis. The average amount of lung tubercle in O. K. cases is 2; in "suspected" cases 4, and in "very suspicious" cases it is 7. There is, however, a marked preponderance of tuberculous cases among the suspected animals.

Unfortunately in this matter, general averages and tendencies and "majorities" count for nothing, so long as the object is to discover individual cases. Each animal has its own strong individuality; it should not be judged by its fellows. I suspect, too, that each herd has its own individuality.

TABLE XVI.

The Vandruff Herd, Injected January 12th, 1894.

NAME OF ANIMAL.	Mark.	Temperature when Injected. 9–10 p. m.	Period IV. 6:30 a. m.	Period V. 9:30 a. m.	Period VI. 2 p. m.	Period VII. 4:30 p. m.	Range.	Rise from Initial Temperature.	Maximum Temperature.	Time to Maximum Temperature.	Time of Maximum Temperature.	PHYSICAL CONDITION.
										hrs.		
Black Heifer	Bl.	101.5°	101.5°	100.8°	102.5°	100.0°	2.5°	1.0°	102.5°	16	2 p. m.	Sound.
Jumbo	J.	100.8°	100.8°	100.4°	101.6°	100.5°	1.2°	0.8°	101.6°	16	2 p. m.	Recovering from garget.
Yellow Heifer	Y.	100.8°	100.6°	99.6°	101.0°	....	1.4°	0.2°	101.0°	16	2 p. m.	Partly recovered from garget.
Gray Heifer	G.	100.8°	100.8°	99.8°	101.4°	....	1.6°	0.6°	101.4°	16	2 p. m.	Partial recovery from garget.
Ollie	O.	103.2°	103.2°	102.5°	102.8°	102.0°	1.2°	Fall.	103.2°	....	9 p. m.	Severe case of garget, etc.
Brown Heifer	Bro.	100.8°	100.8°	100.8°	101.0°	....	0.2°	0.2°	101.0°	16	2 p. m.	Suffering from garget.
Star Cow	S.	102.1°	100.4°	100.0°	101.0°	....	2.1°	Fall.	102.1°	....	9 p. m.	Suffering from garget.
Brindle Cow	Bri.	100.6°	100.8°	100.2°	101.0°	....	0.8°	0.8°	101.0°	16	2 p. m.	Nearly recovered from garget.

OTHER HERDS.

Table XVI. shows the data observed on the Vandruff herd, near Deckertown, N. J. This certainly presents a remarkable case in Ollie, who, in many respects, suggested our Case 1. The temperature curve is almost identically similar. No doubt would have remained in my mind of this cow being tuberculous had she been alone. But so many other members of this herd had been sick "like her" and were recovering, and showed no reaction, that I concluded that this herd was free from tuberculosis—pneumonia and mammitis being probably the true diseases present, and accounted for the high temperature of Ollie. Nevertheless, the possibility remains that this one animal may be tuberculous, although from the evidence I had, I was not justified in diagnosing a case of this disease.

I have already referred to the work of other men, and three or more sets of their temperature tables lie before me. Were these temperatures recorded in connection with those presented in my tables, I would be justified in putting the mark of condemnation upon many cases that have been "passed" as sound. But I dare not go so far as to pronounce judgment against these creatures whom, in the first place, I have never studied, and, in the second place, are members of herds with peculiarities different from our own. I merely mention this to emphasize the point that we need to experiment along these lines with greater care than ever.

There should be no unscientific haste. For thousands of years have we battled with these unseen and undreamed-of germs, and now that we know them, let us study them more carefully. If legislation be needed to aid in the stamping out of this disease, let the work be done thoroughly and not superficially. It is not for the experimenter to pronounce on the advisability of certain features of a law on this subject, *e. g.* the matter of pecuniary reimbursement by the public to the loser of tuberculous animals. I would merely suggest that if the matter be brought properly before the public, the people will insist on getting milk from herds that have stood this test. Thus will dairymen be compelled, for their own interests, to call in the veterinarian—first, to test the herd; secondly, to disinfect the premises; thirdly, to suggest sanitary modifications in the stables, and lastly, to test all newcomers. This work no doubt is expensive, *but it will pay.*

I would also suggest that if the State assume control of this business of stamping out tuberculosis, that first of all the temperature record of each cow be published, and that all suspected cases be quarantined until we know about how many cases there are, then it will be easier to judge what strain the treasury will stand. But, seriously, these cows should not be slaughtered until they have been properly studied. We need to know a good deal more about many points; all those studied in connection with our rather meager data should be viewed from a broader standpoint, but especially do we need to know more about the methods of infection and the presence of bacilli in the milk. We ought also to know to what extent it is true that a second injection produces a greatly reduced reaction, as suggested from the work of Dr. Pearson. There should also be a series of analyses made of the meat of tuberculous animals to see to what extent tuberculin may be stored in the tissues, so as to be an element of danger as presupposed by Dr. Low in his recent pamphlet issued from the Cornell Station, N. Y. A pamphlet, by the way, which gives an admirable synopsis of what is known about tuberculosis, in more detail than our section 2.

SUMMARY OF CONCLUSIONS.

In summarizing this paper only the last section will receive extended attention. Section 1 outlines the work done in stamping out tuberculosis at the College farm. Forty-one animals were injected with tuberculin; twenty-four showed reaction, and the autopsies revealed tuberculous lesions in all except two doubtful cases. Half, only, of these cases had been "suspected" from physical examination.

Section 2 considers among other things the question of liability to infection, in man, from the milk of tuberculous cows; discussion of the work of other observers on these subjects being presented.

Section 3 is a record or journal of the operations in connection with the autopsies. Samples of milk and of various organs were preserved for microscopic work, to be prosecuted later.

Section 4 presents the tables of data, both those ascertained by direct observation, and those from calculation, together with a detailed comparison of the facts to discover co-variants. The following results are those most clearly indicated:

(1) A "reaction" consists in the recognition, by the body, of the resence of toxines, to which the previous presence of tubercle bacilli as rendered the tissues sensitive. It is incapable of exact measureient and can best be determined from a calculated normal, the locaon of which can be approximately fixed from an extended series of emperature observations on the individual whose record is in doubt. t can also be located as being certainly below a fixed maximum etermined for the herd, and, finally, the initial temperature gives a lue to it, because the latitude of individual variation is only half iat of the herd as a whole, viz., about 2.2°. Furthermore, the ssociations of normal temperatures with the initial evening record is ich that a yet closer approximation may be made. The special rules overning this for the different hours of the day and for various temeratures are presented with Table IX.

(2) Thus, the determination of the reaction reduces itself to a revion of the ordinary method (that, viz., by taking the difference etween the initial temperature and the maximum record) by incororating the principle that the temperature of an animal tends to ibrate about a fixed mean, with fixed maximal limits of oscillation, eyond which any excess must be certainly predicated as a reaction. 'urthermore, that this reaction is an extended affair, the true total eaction being the integral of the reaction curve.

(3) The duration of a reaction is proportional to the greatest height iereof.

(4) The higher the reaction the sooner it occurs.

(5) The height of reaction is no index to the amount of tuberculosis present.

(6) The amount of tuberculosis increases regularly with the age of he victim.

(7) There is little difference between the different breeds of highred cattle, so far as their susceptibility to tuberculosis goes; but rades, crosses and especially "native" cattle appear somewhat less ubject to its development.

(8) The total reaction tends to be greater in cases of slight than in ases of well-developed tubercle.

(9) The normal temperatures of young animals range higher than hose of the older ones.

(10) While the diagnosis of tubercle from physical examination is dependent on the presence of tubercle in the lungs, there is no certainty that even well-advanced cases can be thus discovered, nor does it necessarily follow that all suspected tuberculous animals have lesions of the lungs. In the absence of lung lesions, however, the chance of discovery of advanced cases of this disease by physical means is but slight. It also happens that a number of cows not suffering from tubercle are usually included as "suspected" by this sort of diagnosis. Certainly at least twice as great accuracy in discovering tuberculous cattle results from the use of Koch's lymph as from all other means combined.

(11) Slight cases of reaction may occur later than fifteen hours after injection; and, to be certain that all cases have been given a chance to make a record, the observations following injection should be continued for twenty-four hours at least.

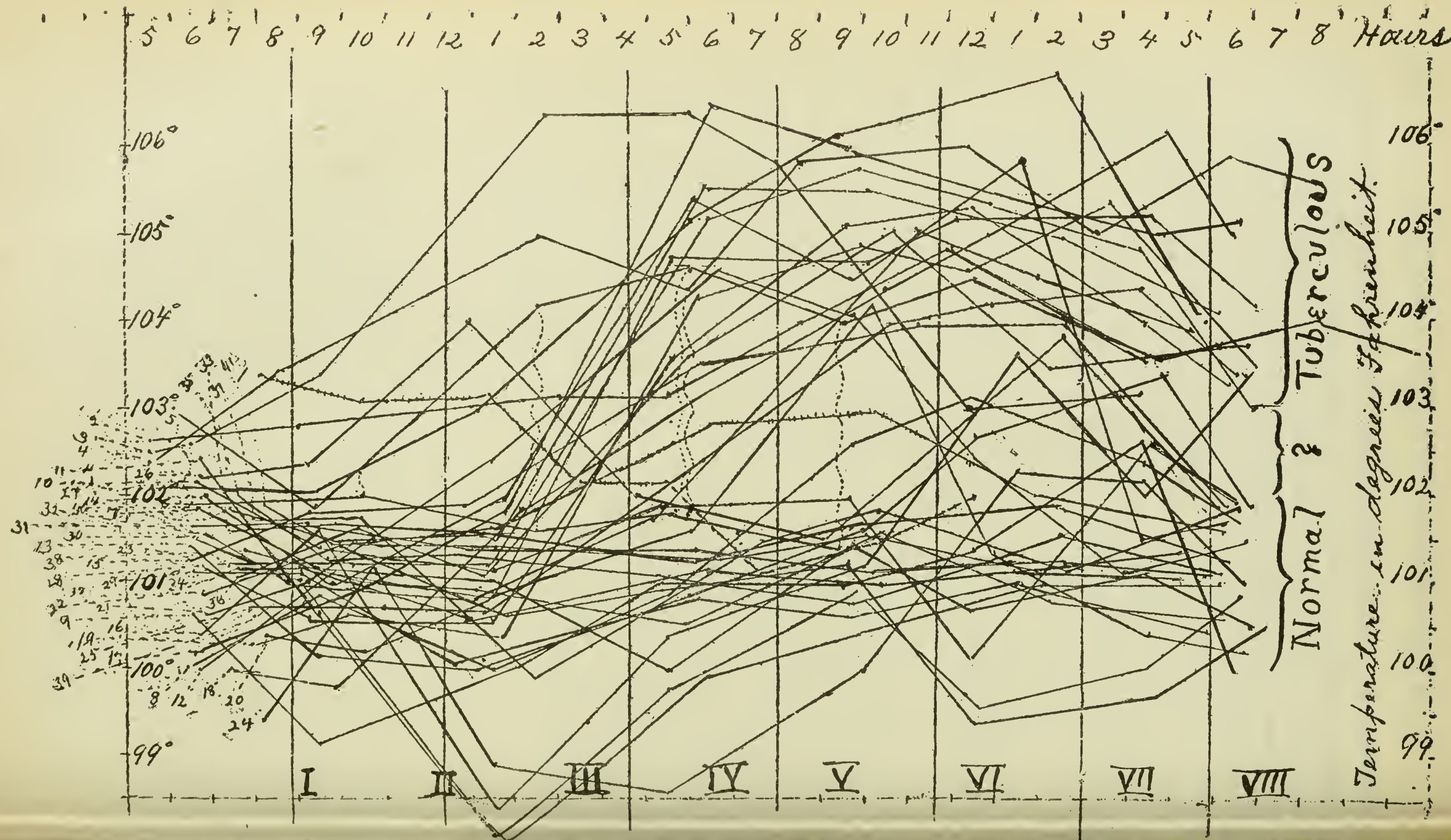
(12) If the object of injection be to eradicate the disease utterly from a herd, the reacting cases should be arranged in the order of the certainty of the reaction (in a few cases it will be needful to continue the temperature observations for several days to gain a knowledge of the probable "normal") and killed *seriatim* until among the doubtful cases there occur at least two in immediate succession which are adjudged sound after extremely thorough examination of all lymphatic structures and places where connective tissue abounds. Then the premises should be thoroughly cleaned and disinfected, and no new animals admitted until they have passed the "test." Finally, to keep the herd "clean," the animals should be tested annually or biennially.

ACKNOWLEDGMENTS.

In conclusion, I desire to acknowledge, with thanks, the various services rendered me by the different persons named below. These services have been of material aid to me and to the securing of the data for this publication. Dr. Leonard T. Pearson, of Philadelphia, Professor in the Veterinary Department of the University of Pennsylvania, for kindly granting me several audiences in which conference was had on my work and valuable directions given as to procedure; Dr. Henry R. Baldwin, for much general direction, counsel

nd interest in the autopsies; Dr. A. V. N. Baldwin, for assistance several autopsies; Dr. E. L, Loblein, veterinarian, for personal nducting of many of the examinations; last, though not least, Mr. . A. Jones, who observed nearly all the temperatures—perhaps the ost important and arduous portion of the work.

JULIUS NELSON, Ph.D.,
Biologist.

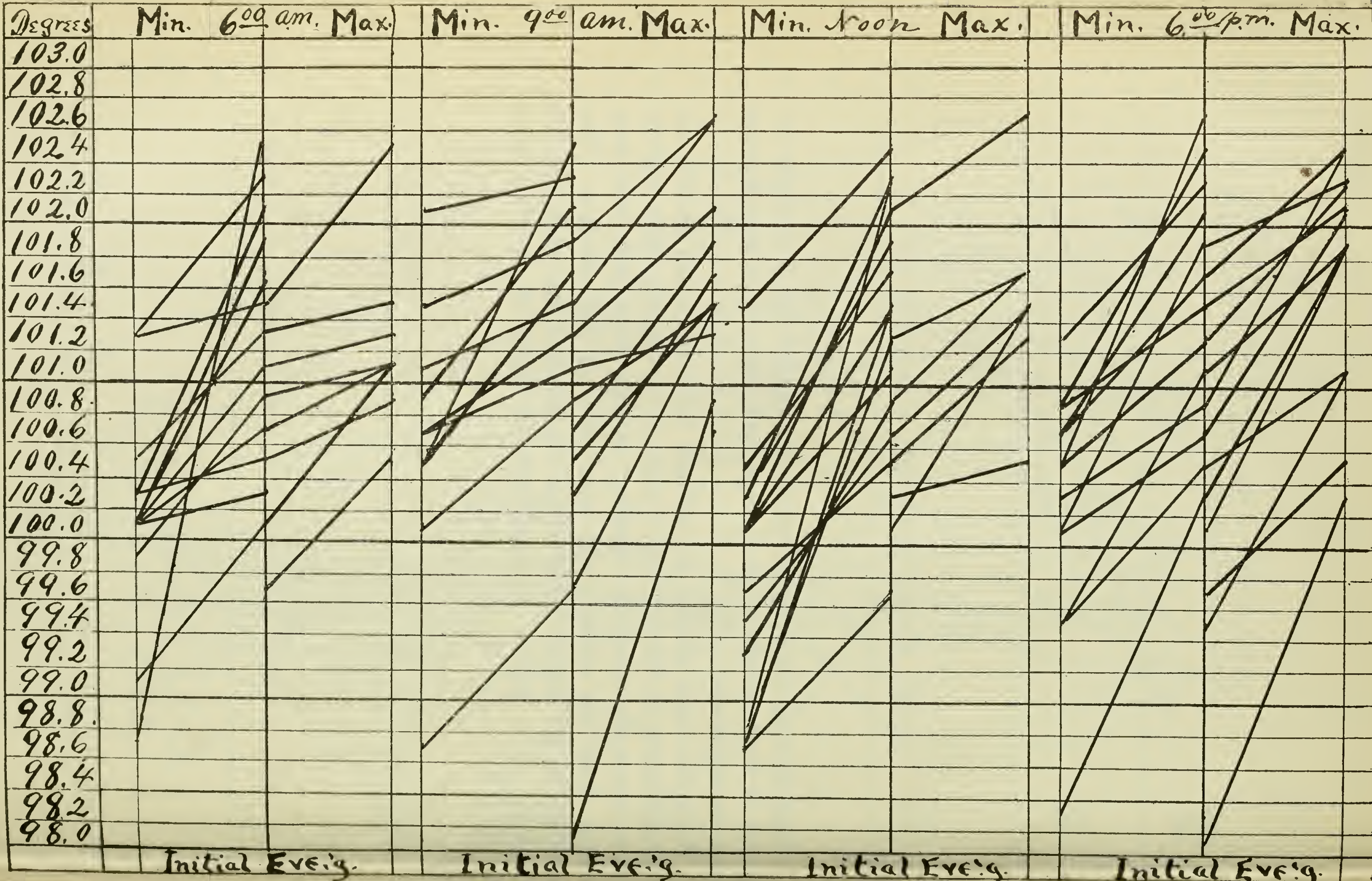


Hours
Tuberculous
Normal
Temperature in degrees Fahrenheit.
106°
105°
104°
103°
102°
101°
100°
99°
I
II
III
IV
V
VI
VII
VIII

EXPLANATION OF CHART I.

Chart showing temperature curves for twenty-four hours after in-
:tion of the members of the College herd, each curve kept separate
)m its neighbors.

While two main courses are pursued by these curves, namely, the
›ward course in Period III. of most of the reacting cases, and the
wer course for those not reacting, we find many cases that vary
dely from the average, and some cases of late reaction. The
ımbers at the top of the plate are the hours of the night and the
ytime. The degrees of temperature are shown at the sides from
° to 106°.

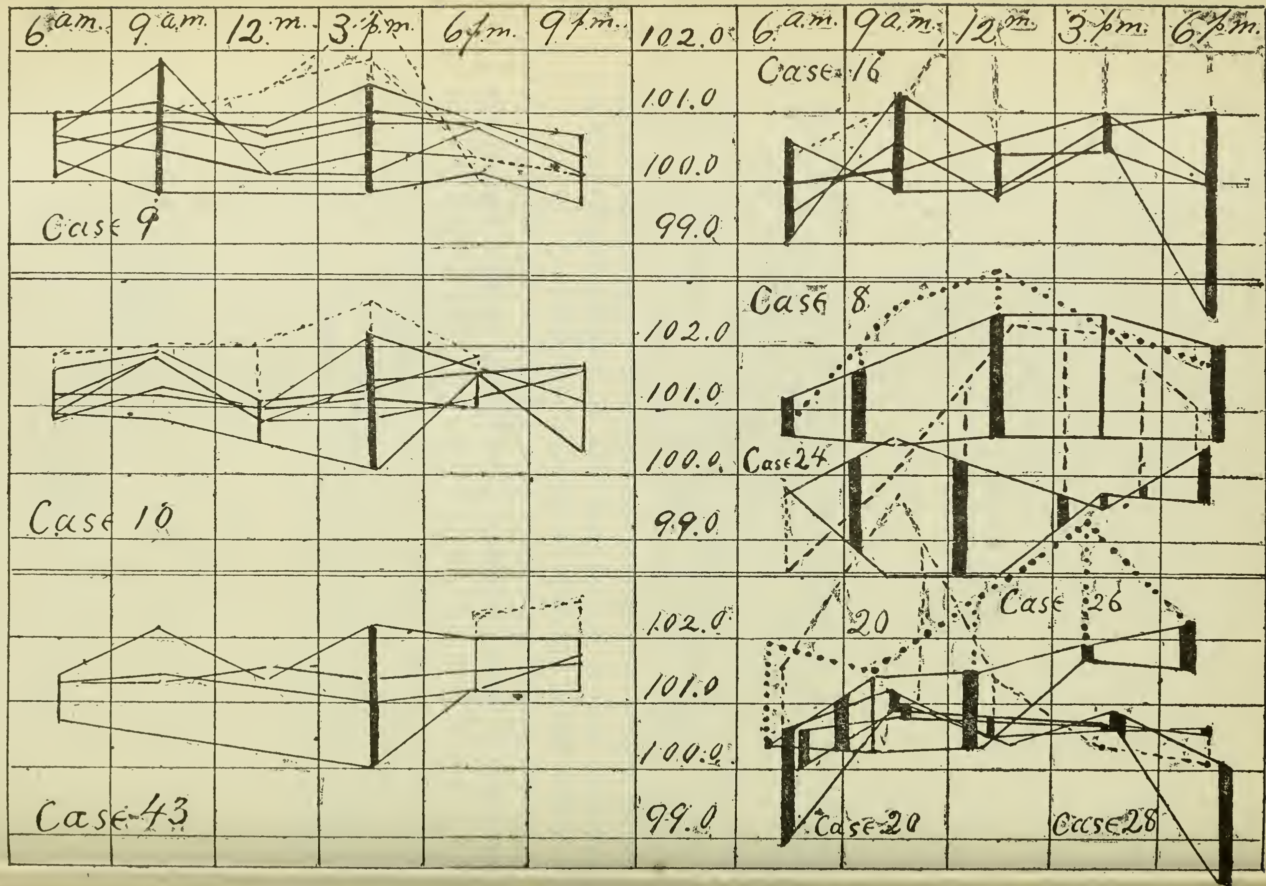

Degrees
Min. 6.00 am. Max.
Min. 9.00 am. Max.
Min. Noon Max.
Min. 6.00 p.m. Max.
103.0
102.8
102.6
102.4
102.2
102.0
101.8
101.6
101.4
101.2
101.0
100.8
100.6
100.4
100.2
100.0
99.8
99.6
99.4
99.2
99.0
98.8
98.6
98.4
98.2
98.0
Initial Eve'g.
Initial Eve'g.
Initial Eve'g.
Initial Eve'g.

EXPLANATION OF CHART II.

Chart showing the association of temperatures at critical periods, with initial evening temperature, for non-reacting cases in the College herd. Morning, forenoon, noon and evening, periods are shown.

The central vertical line in each period represents the scale of initial evening temperatures, the degrees of which are shown at the left of the plate. On the right-hand side of each period the rising lines show the highest temperatures associated with the particular evening temperature, and on the left-hand side the lines slanting down from the middle vertical one show the minimal associations.

A general parallelism in these lines suggests the law which for all periods may be stated as follows: The highest expected temperature for any period does not exceed 102.6°, nor fall below 100.2°, and between these points is roughly 1° above the initial evening temperature. Especially in the morning is a rise of more than a degree above the initial evening temperature (between 100° and 102.6°) to be looked at with suspicion, if injection has taken place.


6 a.m.
9 a.m.
12 m.
3 p.m.
6 p.m.
9 p.m.
102.0
101.0
100.0
99.0
6 a.m.
9 a.m.
12 m.
3 p.m.
6 p.m.
Case 9
Case 10
Case 43
Case 16
Case 8
Case 24
Case 26
20
Case 20
Case 28

EXPLANATION OF CHART III.

Chart showing ranges of temperature in individual cases. Six equal scales are drawn. The heavy vertical lines show the ranges, the dotted "curves" represent injection temperatures, the unbroken ones are normal temperatures, the broken vertical lines show the extent of the probable reaction, positive or negative, for the different periods.

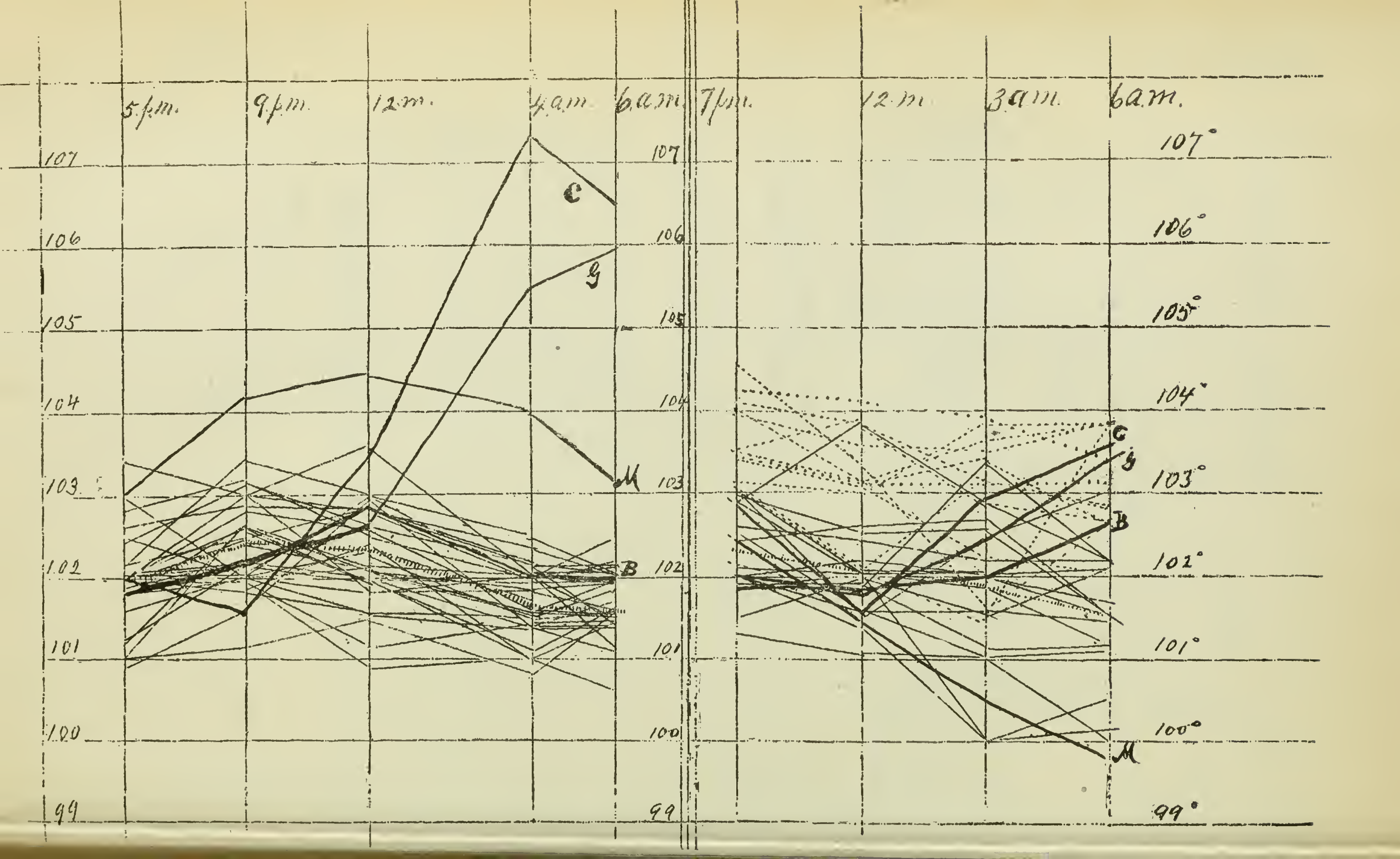
In Case 9, the lower dotted line represents the second injection.

In Case 10, the noon reaction is greater than that of the afternoon, even though the temperature was rising.

In Case 43, the injection occurred in the morning, so that only a small part of the reaction curve coincides with the other curve periods, the record not being begun before 6 P. M.

Case 8, compared with Case 24 (both tuberculous), shows, first, that a true reaction curve may lie below the normal of a different case, and secondly, that a rise of only half a degree above normal, if the latter be already high, indicates a true reaction. In this instance there was a rise of more than two degrees above initial temperature, but a higher initial was possible, and such would have probably had a lower normal at noon, thus tending to increase the "real" reaction while lessening the "calculated" one.

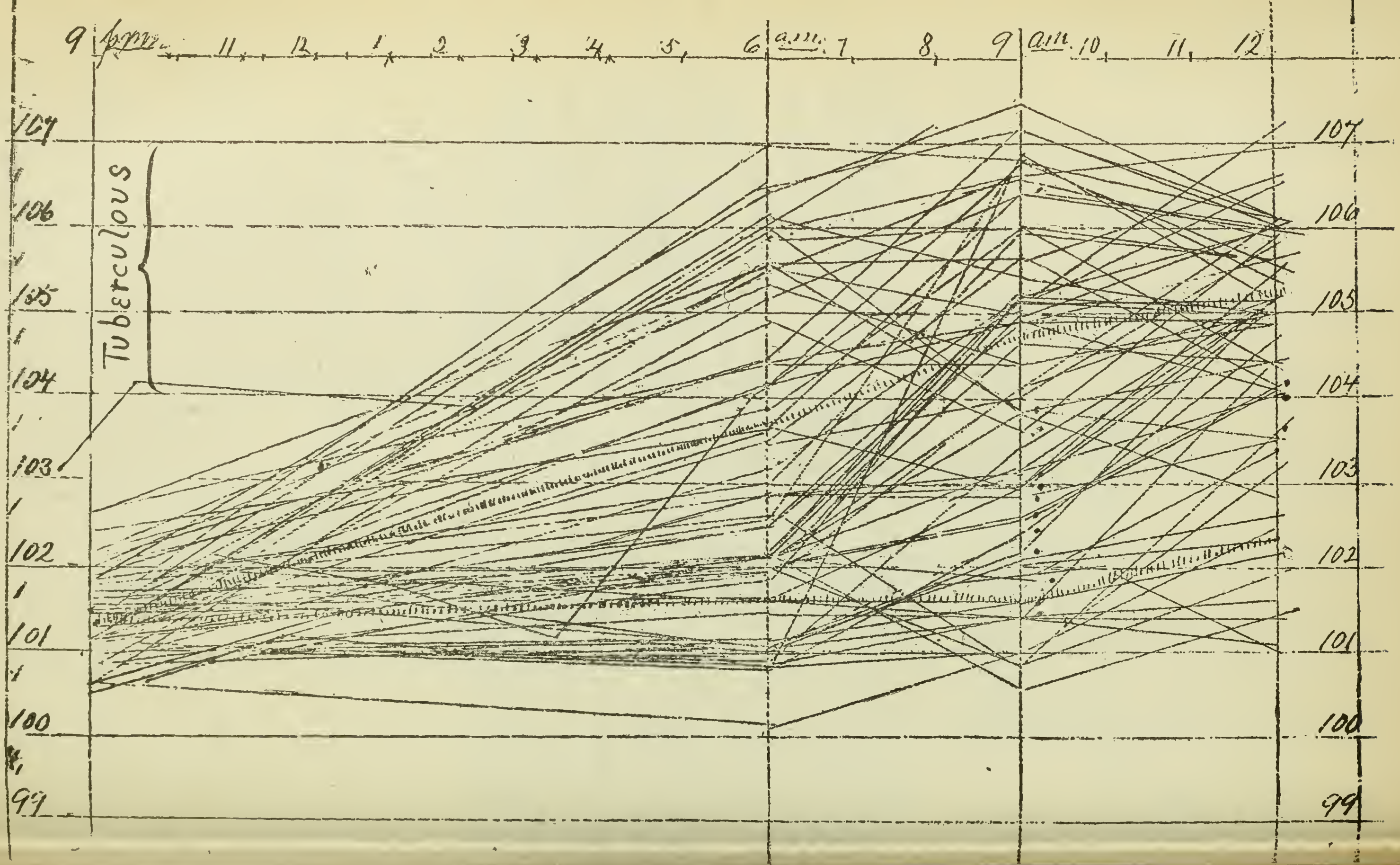
In the sixth scale, three cases (20, 26 and 28) have been plotted, the reaction curves being shown for two of them (20 and 26).


5 p.m.
9 p.m.
12 m.
4 a.m.
6 a.m.
7 p.m.
12 m.
3 a.m.
6 a.m.
107
106
105
104
103
102
101
100
99
107°
106°
105°
104°
103°
102°
101°
100°
99°
C
G
M
B

EXPLANATION OF CHART IV.

Chart showing the temperature curves of Pennsylvania State College herd, injected by Dr. L. F. Pearson. The dotted lines in the ight-hand set of curves show the temperatures for calves. The urves C, G, M, B are of cows injected twice. The right-hand set of curves shows the effect of a second injection on these curves.

Only C and G were condemned, but according to our formula four or five others besides M would have been suspected. It is to be noted, however, that all the temperatures average a degree higher than with our herd, possibly due in part to a different method of taking temperature, viz., deeper insertion, for longer time, and to the fact that these were taken in midsummer, ours in midwinter. It also seems likely that a few cases reacted later in the day. These suggestions are with diffidence put forward only as possibilities, and as incentives to increased carefulness for future observers.



9 pm. 11 12 1 2 3 4 5 6 a.m. 7 8 9 a.m. 10 11 12
107
106
105
104
103
102
101
100
99
Tuberculous

EXPLANATION OF CHART V.

Chart showing temperature curves of the older members of the aylor herd, injected by Dr. Conrow. See "Veterinary Magazine," anuary, 1894.

It will be seen at a glance that the temperature averages higher ıan in our herd and that a higher limit for condemnation was set. 'he dots show curves of uncondemned cases, which had they occurred ı our herd would have been certainly tuberculous. The general ffect of these charts upon the observer is to make it seem a difficult ısk to draw the line between a normal and a "reacting" case.

REPORT OF THE BOTANIST.

REPORT OF THE BOTANIST.

BYRON D. HALSTED, SC.D.

During the year 1893 the work in the Botanical Department has ·en upon several subjects. In the early part of the year attention as chiefly given to the putting in shape of the collection of weeds r the World's Columbian Exposition. In connection with this ork upon weeds for the Chicago exhibit, a check-list was prepared the weeds of America. The list, revised, and with many species ded, is presented in this report.

Several additional sets of North American weeds and a considerable ımber of the collections of weed seeds were ordered by experiment ıtions, agricultural colleges and other institutions. It is also atifying to record that several seed-houses ordered the century of merican weed seeds.

An abnormal growth of potatoes, whereby a considerable loss was casioned to the farmers, has been studied.

In endeavoring to find a quick and easy method of securing pictures leaf diseases a process was developed that, under the name of the landi Method of Sun Printing, is described in this report An plication of the process to the measurement of shrinkage in foliage, also given.

Among injurious fungi to garden crops, special attention has been ven to the club-root of the cabbage, upon which a Bulletin (No. 98, cember 9th, 1893) was issued; the blights of the strawberry, a new emy being found; serious fungous troubles with seedling peas and thracnoses of melons and other truck crops.

The study of the diseases of the violet has been continued, and ose of several other ornamental plants, as the sedums, pelargonium, clamen, dracænas and other palms, primulas, callas, etc.

Bacterial diseases of plants have been studied, and several fungi not ore recorded, which will be described in some botanical journal.

A large number of fungi have been ordered from Europe, an during the coming year the Station herbarium will be enlarged by a least ten thousand specimens.

Weeds at the World's Fair.

The labor of preparing an exhibit of weeds at the Columbia Exposition began early in 1892, but was concluded in 1893, an therefore a record of the work falls within the scope of the presen report.

Primarily the intention was to make as full an exhibit as spac would permit in the botanical alcove of the Experiment Statio Exhibit. This was afterwards extended by complying with a reque for a display in the Department of College Work of the agricultura colleges.

In the spring of 1892 a circular was sent out to botanists and co lectors throughout the country as follows:

WEEDS AT THE WORLD'S COLUMBIAN EXPOSITION.

New Jersey Experiment Station,
New Brunswick, N. J., March 4th, 1892.

Mr. ———— ———— :

Dear Sir—In order that the exhibition of weeds at the World's Columbi Exposition may be large, and representative of all sections of the country, the unde signed (having this feature in charge) respectfully asks for specimens of the wo weeds from all States and Territories.

It is suggested that each botanist or local collector, who may be pleased to ass in the work, secure at least three specimens each of the worst weeds in his State section. In making the specimens it is important that the following points be co sidered: 1. Seeds are especially desired. 2. Seedlings are important in vario stages of development. 3. The root system is essential; also (4) the flower a flower-cluster, and (5) the seed vessel.

It may be necessary, therefore, to secure these various essentials at different tin during the coming season. If the weed is a large one stress is laid upon the proc ing of specimens while they are small enough so that the whole plant, roots and a can be mounted, without bending, upon an herbarian sheet of ordinary size, that not over a foot in length. They are not to be mounted, however, by the collector.

That unnecessary duplication may be avoided, persons who contemplate collecti specimens should signify their intention to the undersigned, and allotments will th be made, the assignments depending largely upon the locality. It is hoped that ea State in the Union may be represented by specimens in this national exhibit of c worst weeds.

The collecting must all be done during the present season, and the specimens s in for mounting, labeling, etc., by December 1st. Correspondence is solicited.

A large correspondence was maintained, the government, through the World's Fair Committee of the Agricultural College Experiment Stations, granting the franking privilege for the purpose. As a result material was obtained sufficient to make a national exhibit. Thanks are due and are here extended to all who assisted in the work.

The two hundred species were mounted upon standard-size herbarium sheets, with printed labels, and are identical with the two centuries of American weeds that have been sent out to a large share of the experiment stations and agricultural colleges in the country. The display was in swinging frames, each holding four sheets and turning upon a large central post.

While it was not possible to secure a picture of the exhibit as a whole after it was in place, a photograph has been taken of one side of a frame, namely, of two species of pigweeds—No. 76, *Amarantus blitoides*, Wats., the "Low Amaranth," and No. 76, *Amarantus chlorotachys*, Willd., the "Green Amaranth." These are shown in Figure 1, and give an idea of the character of the exhibit. They also show how very different two species of the same genus may be, for one is prostrate and the other erect in habit and growth.

In addition to this there was sent a case containing one hundred (100) kinds of weed seeds. This was similar to those that have been sent to many stations and colleges (see last report, page 370), and are still being called for. The list of species is indicated in the check-list by the full-face numbers.

The display of weeds in the botanical alcove was made up independently of that above mentioned and represented the worst species from all sections of the country. On account of lack of space, only a portion of the specimens were displayed upon the walls of the alcove and the balance assumed the form of an herbarium.

In connection with the above work, and in particular to assist the various collectors, a check-list of American weeds was prepared, containing seven hundred and fifty-one species. Opportunity for a thorough revision of this list has been found, and the species given in the display of college work are easily indicated by using numbers varying from one (1) to two hundred (200) in parentheses following the botanical names of the species.

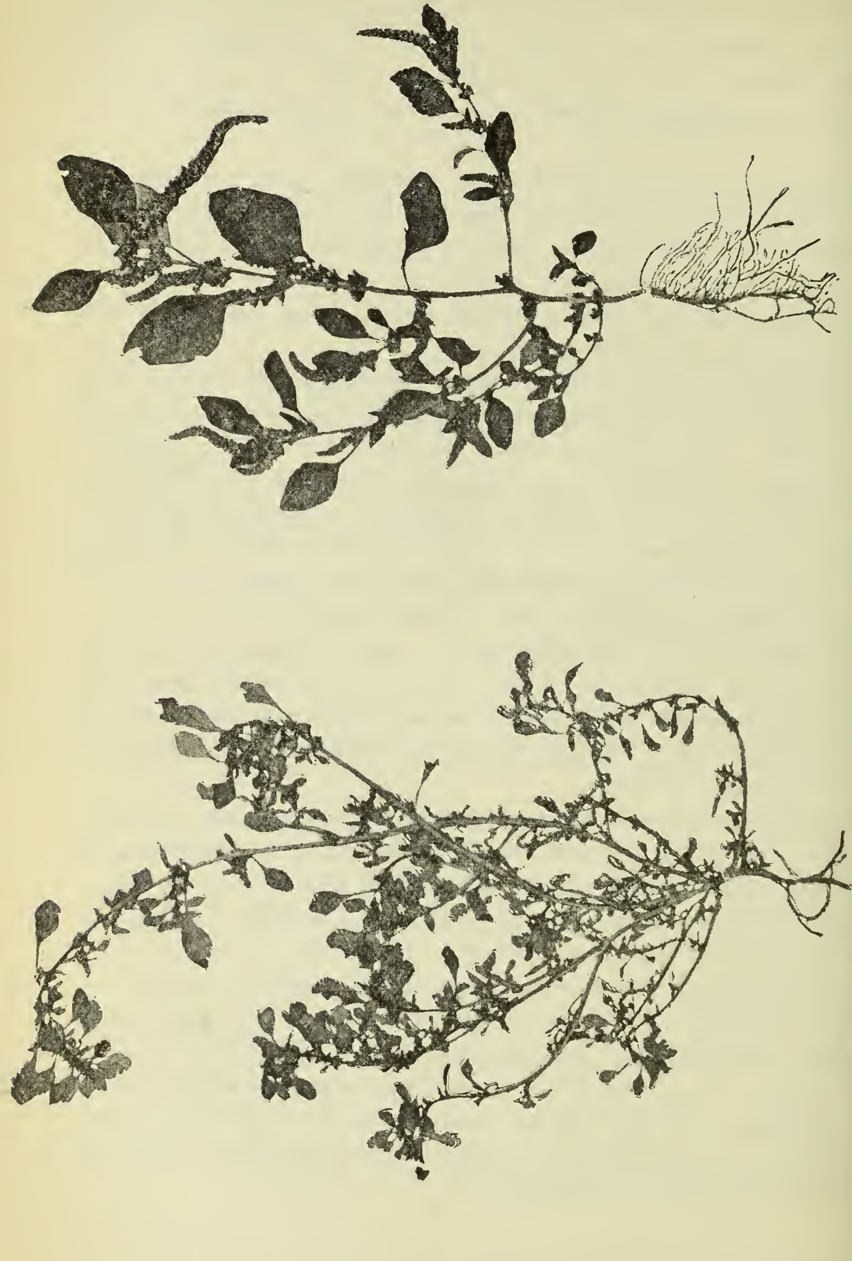


Fig. 1.
Contents of a weed panel at the Columbian Exposition.

CHECK-LIST OF AMERICAN WEEDS—REVISED.

RANUNCULACEÆ.

1 Ranunculus aris, L. (1).
2 Ranunculus bolbosus, L. (2).
3 Ranunculus Californicus, Benth.
4 Ranunculus Pennsylvanicus, L.
5 Ranunculus repens, L.

ANONACEÆ.

6 Asimina grandiflora, Dunal.
7 Asimina parviflora, Dunal.
8 Asimina pygmæa, Dunal.

BERBERIDACEÆ.

9 Berberis vulgaris, L.
10 Podophyllum peltatum, L.

PAPAVERACEÆ.

11 Ageemone Mexicana, L. (101).
12 Ageemone platyceras, Link.
13 Chelidonium majus, L. (102).
14 Eschscholtzia Californica, Cham.
15 Papaver dubium, L.

FUMARIACEÆ.

16 Fumaria officinalis, L.

CRUCIFERÆ.

17 Alyssum calycinum, L.
18 Alyssum maritimum L.
19 Arabis Ludoviciana, Meyer.
20 Barbarea vulgaris, R. Br. (3).
21 Brassica alba, Gray.
22 Brassica campestris, L. (103).
23 Brassica nigra, Koch. (4).
24 Brassica Sinapistrum, Boiss. (5).
25 Camelina sativa, Crantz. (104).
26 Capsella Bursa-pastoris, Mœn. (6).
27 Draba Caroliniana, Walt.
28 Draba cuneifolia, Nutt.
29 Draba verna, L.
30 Erysimum cheiranthoides, L.
31 Lepidium campestre, R. Br. (7).
32 Lepidium intermidium, Gray.
33 Lepidium lasiocarpum, Nutt.
34 Lepidium montanum, Nutt.
35 Lepidium ruderale, L.
36 Lepidium Virginicum, L. (8).
37 Lesquerella Gordoni, Wat.
38 Nasturtium Armoracia, (L.) Fr. (105).
39 Nasturtium obtusum, Nutt.
40 Nasturtium officinale, R. Br.
41 Nasturtium tenacetifolium, H. & A.
42 Raphanus Raphanistrum, L. (9).
43 Raphanus sativus, L.
44 Sisymbrium canescens, Nutt. (106).
45 Sisymbrium canescens, Nutt.; var. brachycarpum, Wats.
46 Sisymbrium incism, Engelm.
47 Sisymbrium officinale, Scop. (10).
48 Sisymbrium Thaliana, Gaud. (107).
49 Thalaspi arvense, L. (108).
50 Tropidocarpum gracile, Hook.

CAPPARIDACEÆ.

51 Cleome integrifolia, F. & G.
52 Cleome pungens, Willd.
53 Cleome serrulata, Pursh. (109).

RESEDACEÆ.

54 Oligomeris glaucescens, Camb.
55 Reseda lutea, L.

CARYOPHYLLACEÆ.

56 Arenaria serpyllifolia, L.
57 Buda rubra, Dumort.
58 Cerastium nutans, Raf.
59 Cerastium viscosum, L. (110).
60 Cerastium vulgatum, L.
61 Dianthus Armeria, L. (111).
62 Lychnis Githago, Lam. (11).
63 Lychnis vespertina, Sibth.
64 Sagina procumbens, L.

65 Saponaria officinalis, L. (12).
66 Saponaria Vaccaria, L. (112).
67 Silene Gallica, L.
68 Silene noctiflora, L. (113).
69 Silene vulgaris, (Mœn.) Garc. (114)
70 Spergula arvensis, L. (115).
71 Stellaria graminea, L.
72 Stellaria media, Sm. (13).

PORTULACACEÆ.

73 Calandrinia Menziesii, Hook.
74 Portulaca oleracea, L. (14).
75 Portulaca pilosa, L.

HYPERICACEÆ.

76 Hypericum mutilum, L.
77 Hypericum nudicaule, Walt.
78 Hypericum perforatum, L. (15).

MALVACEÆ.

79 Abutilon Avicennæ, Gærtn. (16).
80 Hibiscus Trionum, L. (17).
81 Malva borealis, Wallm.
82 Malva moschata, L.
83 Malva parviflora, L.
84 Malva rotundifolia, L. (18).
85 Malveopsis coccinia (Pursh.), Ktz. (116).
86 Modiola multifida, Mœnch.
87 Sida cordifolia, L.
88 Sida hederacea, Torr.
89 Sida rhombifolia, L.
90 Sida spinosa, L. (117).
91 Sphæralcea pedata, Torr.
92 Urena lobata, L.

STERCULIACEÆ.

93 Melochia pyramidata, L.
94 Triumfetta semitriloba, L.

LINACEÆ.

95 Linum usitatissimum, L.

GERANIACEÆ.

96 Erodium Botrys, Bertol.
97 Erodium cicutarium, L'Her. (118).
98 Erodium moschatum, Willd.
99 Geranium Carolinianum, L.
100 Impatiens fulva, Nutt.
101 Oxalis Acetosella, L.
102 Oxalis corniculata, L.; var. stricta, S.
103 Oxalis violacea, L.
104 Oxalis Wrightii, Gray.

CELASTRACEÆ.

105 Ceanothus microphyllus, Michx.

ANACARDIACEÆ.

106 Rhus glabra, L.
107 Rhus diversiloba, T. & G.
108 Rhus radicans, L. (119).
109 Rhus typhina, L.

LEGUMINOSÆ.

110 Amorpha canescens, Nutt. (120).
111 Amorpha microphylla, Pursh.
112 Apios tuberosa, Mœnch.
113 Astragalus caryocarpus, Ker.
114 Astragalus mollissimus, Torr.
115 Baptisia tinc oria, R. Br.
116 Cassia Chamæcrista, L. (121).
117 Cassia Marylandica, L.
118 Cassia Occidentalis, L.
119 Cassia Tora, L.
120 Chapmania Floridana, T. & G.
121 Crotalaria ovalis, Pursh.
122 Crotalaria Purshii, DC.
123 Crotalaria sagittalis, L. (122.)
124 Desmodium canescens, DC.
125 Desmodium cuspidatum, T. & G.
126 Desmodium Floridanum, Chapm.
127 Desmodium molle, DC.
128 Galactia Elliottii, Nutt.
129 Galactia pilosa, Ell.
130 Genista tinctoria, L.
131 Gleditschia triacanthos, L.
132 Glycyrrhiza lepidota, Nutt. (123).
133 Hosackia Purshiana, Benth.

134 Indigofera tinctoria, L.
135 Lathyrus paluster, L.
136 Lespedeza capitata, Michx.
137 Lespedeza striata, Hook. & Arn.
138 Lupinus densiflorus, Benth.
139 Lupinus flexuosus, Lindl.
140 Lupinus formosus, Grev.
141 Medicago denticulata, Willd.
142 Medicago lupulina, L. (19).
143 Medicago maculata, Willd.
144 Medicago sativa, L.
145 Melilotus alba, Lam. (20).
146 Melilotus Indica, All.
147 Melilotus officinalis, Willd. (124).
148 Mimosa strigillosa, T. & G.
149 Oxytropis Lamberti, Pursh.
150 Phaseolus diversifolius, Pers.
151 Phaseolus perennis, Walt.
152 Psoralea campestris, Nutt.
153 Psoralea tenuiflora, Pursh.
154 Schrankia uncinata, Willd.
155 Sesbania Cavanillesii, Watson.
156 Sesbania macrocarpa, Muhl.
157 Termopsis Montana, Nutt.
158 Trifolium agrarium, L.
159 Trifolium amphianthum, T. & G.
160 Trifolium arvense, L. (125).
161 Trifolium medium, L.
162 Trifolium reflexum, L.
163 Trifolium repens, L.
164 Trifolium hybridum, L.
165 Vicia Cracca, L.
166 Vicia sativa, L. (126).
167 Vicia tetrasperma, Loisel.

ROSACEÆ.

168 Agrimonia striata, Michx. (127).
169 Chamæbatia foliolosa, Benth.
170 Fragraria Indica, Andr.
171 Potentilla argentea. L.
172 Potentilla Canadensis, L. (128).
173 Potentilla fruticosa, L.
174 Potentilla Norvegica, L.
175 Potentilla supina, L.
176 Potentilla recta, L.
177 Poterium Canadense, B. & H.
178 Poterium Sanguisorba, L.
179 Rosa Arkansana, Porter. (129).
180 Rosa acicularis, Lindl. (130).
181 Rosa blanda, Ait.
182 Rosa Californica, Cham. & Schl.
183 Rosa Carolina, L.
184 Rubus Canadensis, L.
185 Rubus cuneifolius, Pursh.
186 Rubus trivialis, Michx.
187 Rubus ursinus, Cham. & Schl.
188 Rubus villosus, Ait.
189 Spiræa salicifolia, L.

CRASSULACEÆ.

190 Penthorium sedoides, L.
191 Sedum Rhodiola, DC.
192 Sedum Telephium, L. (21).

LYTHRACEÆ.

193 Cuphea petiolata.
194 Lythrum alatum, Pursh.

ONAGRACEÆ.

195 Epilobium coloratum, Muhl.
196 Epilobium paniculatum, Nutt.
197 Epilobium spicatum, Lam.
198 Gaura angustifolia, Michx.
199 Gaura biennis, L.
200 Gaura coccinea, Nutt.
201 Gaura parviflora, Dougl.
202 Œnothera biennis, L. (22).
203 Œnothera sinuata, L. (131).
204 Œnothera speciosa, Nutt.
205 Œnothera ovata, Nutt.
206 Œnothera pinnatifida, Nutt.
207 Ludwigia virgata, Michx.

LOASACEÆ.

208 Mentzelia nuda, T. & G.

PASSIFLORIACEÆ.

209 Passiflora incarnata, L. (23).

CUCURBITACEÆ.

210 Cucurbita fœtidissima, HBK.
211 Echincystis lobata, T. & G.

212 Megarrhiza Oregana Torr.
213 Melothria pendula, L.
214 Sicyos angulatus, L.

CACTACEÆ.

215 Opuntia Missouriensis, DC.
216 Opuntia Rafinesquii, Engelm.
217 Opuntia vulgaris, Haworth.

FICOIDEÆ.

218 Mollugo verticillata, L. (24).
219 Sesuvium pentandrum, Ell.

UMBELLIFERÆ.

220 Æthusa Cynapium, L.
221 Angelica atropurpurea, L.
222 Apium graveolens, L.
223 Carum Carui, L.
224 Chærophyllum sativum, Lam.
225 Cicuta maculata, L.
226 Conium maculatum, L.
227 Daucus Carota, L. (25).
228 Daucus pusillus, Michx.
229 Eryngium yuccæfolium, Michx.
230 Fœniculum officinale, All.
231 Heracleum lanatum, Michx.
232 Hydrocotyle Americana, L.
233 Hydrocotyle umbellata, L.
234 Osmorrhiza brevistylis, DC.
235 Osmorrhiza longistylis, DC.
236 Pastinaca sativa, L. (26).
237 Thaspium aureum, Nutt.

CAPRIFOLIACEÆ.

238 Sambucus Canadensis, L.
239 Symphoricarpos occidentalis, Hook. (132).

RUBIACEÆ.

240 Diodia teres, Walt. (27).
241 Galium verum, L.
242 Oldenlandia glomerata, Michx.
243 Richardia scabra, L. (133).
244 Rubia tinctoria, L.

DIPSACEÆ.

245 Dipsacus Fullonum, L.
246 Dipsacus sylevestris, Mill. (28).

COMPOSITÆ.

247 Acanthospermum xanthioides, DC.
248 Achillea Millefolium, L. (29).
249 Achyrachæna mollis, Schauer.
250 Ambrosia artemisiæfolia, L. (30).
251 Ambrosia psilostachya, DC.
252 Ambrosia trifida, L. (31).
253 Antennaria plantaginifolia, Hook. (134).
254 Anthemis arvensis, L. (32).
255 Anthemis Cotula, L. (33).
256 Aplopappus divaricatus, Gray.
257 Aplopappus rubiginosus, T. & G.
258 Arctium Lappa, L. (34).
259 Artemisia annua, L.
260 Artemisia biennis, Willd.
261 Artemisia Caudata, Michx.
262 Artemisia vulgaris, L.
263 Artemisia vulgaris, L.; var. Californica, Bess.
264 Aster angustus, T. & G.
265 Aster cordifolius, var. lævigatus, Porter.
266 Aster Drummondii, Lindl.
267 Aster ericoides, L.
268 Aster multiflorus, Ait.
269 Aster Novæ-Angliæ, L.
270 Aster Novi-Belgii, L.
271 Aster tenacetifolius, HBK.
272 Baccharis Douglasii, DC.
273 Baccharis pilularis, DC.
274 Baccharis viminea, DC.
275 Bahia oppositifolia, Nutt.
276 Bellis perennis, L.
277 Bidens bipinnata, L. (35).
278 Bidens cernua, L.
279 Bidens chrysanthemoides, Michx.
280 Bidens connata, Muhl.
281 Bidens frondosa, L. (36).
282 Bidens pilosa, L.
283 Cacalia atriplicifolia, L.
284 Cacalia tuberosa, Nutt.
285 Carduus nutans, L.
286 Centaurea Cyanus, L.

287 Centaurea Jacea, L.
288 Centaurea Melitensis, L.
289 Centaurea nigra, L.
290 Centaurea solstitialis, L.
291 Chondrilla juncea, L.
292 Chrysanthemum Leucan., L.
293 Chrysanthemum Parthenium, Pers.
294 Chrysopsis falcata, Ell.
295 Chrysopsis villosa, Nutt.
296 Cichorium Intybus, L. (38).
297 Cnicus altissimus, Willd.
298 Cnicus altissimus, W.; v. discolor G.
299 Cnicus arvensis, Hoffm. (39).
300 Cnicus edulis, Gray.
301 Cnicus horridulus, Pursh.
302 Cnicus lanceolatus, Hoffm. (135).
303 Cnicus ochrocentrus, Gray.
304 Cnicus pumilus, Torr.
305 Cnicus undulatus, Gray.
306 Coreopsis aristosa, Michx.
307 Coreopsis trichosperma, Michx.
308 Cotula coronopifolia, L.
309 Cotula vulgaris, L.
310 Crepis occidentalis, Nutt.
311 Crepis virens, L.
312 Dysodia chrysanthemoides, Lag.
313 Erechtites hieracifolia, Raf. (40).
314 Erigeron annuus, Pers. (136).
315 Erigeron bellidifolius, Muhl.
316 Erigeron Canadensis, L. (41)
317 Erigeron Philadelphicus, L.
318 Erigeron ramosus, Walt. (42).
319 Eupatorium coronopifolium, Willd.
320 Eupatorium fœniculaceum, Willd.
321 Eupatorium perfoliatum, L.
322 Eupatorium purpureum, L.
323 Franseria discolor, Nutt. (137).
324 Franseria Hookeriana, Nutt.
325 Franseria tenuifolia, Gray.
326 Franseria tomentosa, Gray.
327 Galinsoga parviflora, Cav. (138).
328 Gnaphalium decurrens, Ives.
329 Gnaphalium microcephalum, Nutt.
330 Gnaphalium palustre, Nutt.
331 Gnaphalium polycephalum, Michx.
332 Gnaphalium purpureum, L.
333 Gnaphalium ramosissimum, Nutt.
334 Gnaphalium Sprengelii, H. & A.
335 Gnaphalium uliginosum, L. (139).
336 Grindelia lanceolata, Nutt
337 Grindelia robusta, Nutt.
338 Grindelia squarrosa, Dunal.
339 Helenium autumnale, L.
340 Helenium tenuifolium, Nutt. (43).
341 Helianthus annuus, L.
342 Helianthus Californicus, DC.
343 Helianthus doronicoides, Lam.
344 Helianthus Floridanus, Gray.
345 Helianthus grosse-serratus, M.
346 Helianthus Maximiliani, Schrad.
347 Helianthus petiolaris, Nutt.
348 Helianthus rigidus, Desf.
349 Helianthus strumosus, L.
350 Helianthus tuberosus, L.
351 Hemizonia fasiculata, T. & G.
352 Hemizonia luzulæfolia, DC.
353 Heterotheca grandiflora, Nutt.
354 Hieracium aurantiacum, L. (44).
355 Hieracium præaltum, Vill.
356 Hypochærus radiata.
357 Inula Helenium, L.
358 Iva axillaris, Pursh. (140).
359 Iva ciliata, Willd.
360 Iva xanthiifolia, Nutt. (141).
361 Lactuca acuminata, Gray.
362 Lactuca Canadensis, L. (142).
363 Lactuca Floridana, Gærtn.
364 Lactuca graminifolia, Michx.
365 Lactuca integrifolia, Bigel.
366 Lactuca Ludoviciana, DC.
367 Lactuca Scariola, L. (45).
368 Lampsana communis, L.
369 Leontodon autumnalis, L.
370 Lepachys pinnata, T. & G.
371 Liatris pycnostachya, Michx.
372 Lygodesmia juncea, Don. (143)
373 Madia glomerata, Hook.
374 Madia sativa, Molina.
375 Madia sativa, var. congesta, T. & G. (144).
376 Matricaria discoidea, DC.
377 Matricaria inodora, L.
378 Matricaria occidentalis.
379 Melanthera hastata, Michx.
380 Onopordon acanthium, L.
381 Picris hieracioides, L.
382 Prenanthes alba, L.
383 Prenanthes altissima, L.

384 Pyrrhopappus Carolinianus, DC.
385 Rudbeckia hirta, L. (46).
386 Rudbeckia laciniata, L.
387 Rudbeckia speciosa, Wend.
388 Senecio lobatus, Pers. (145).
389 Senecio viscosus, L.
390 Senecio vulgaris, L. (146).
391 Silphium integrifolium, Michx.
392 Silphium laciniatum, L.
393 Silybum Marianum, Gærtn.
394 Solidago Canadensis, L. (147).
395 Solidago juncea, Ait.
396 Solidago lanceolata, L. (148).
397 Solidago Missouriensis, Nutt.
398 Solidago nemoralis, Ait.
399 Solidago rigida, L.
400 Solidago rugosa, Mill.
401 Solidago serotina, Ait.
402 Solidago speciosa, Nutt.
403 Solidago tenuifolia, Pursh.
404 Sonchus arvensis, L. (149).
405 Sonchus asper, Vill. (150).
406 Sonchus oleraceus, L. (47).
407 Stephanomeria paniculata, Nutt.
408 Tanacetum vulgare, L. (151).
409 Taraxacum officinale, Weber. (48).
410 Tragopogon porrifolius, L.
411 Tragopogon pratensis, L. (152).
412 Vernonia angustifolia, Michx.
413 Vernonia Arkansana, DC.
414 Vernonia Baldwinii, Torr.
415 Vernonia fasciculata, Michx.
416 Vernonia Noveboracensis, Willd. (153).
417 Xanthium Canadense, Mill. (49).
418 Xanthium Canadense, M.; var. echinatum, Gray.
419 Xanthium spinosum, L. (154).
420 Xanthium strumarium, L.

LOBELIACEÆ.

421 Lobelia inflata, L. (155).
422 Lobelia syphilitica, L.

CAMPANULACEÆ.

423 Campanula glomerata, L.
424 Heterocodon rariflorum, Nutt.
425 Specularia perfoliata, ADC. (156).

PRIMULACEÆ.

426 Anagallis arvensis, L.
427 Lysimachia stricta, Ait.
428 Lysimachia nummularia, L. (157).

EBENACEÆ.

429 Diospyros Virginiana, L.

APOCYNACEÆ.

430 Apocynum androsæmifolium, L. (158).
431 Apocynum cannabinum, L. (50).

ASCLEPIADACEÆ.

432 Asclepias Syriaca, L.
433 Asclepias eriocarpa, Benth.
434 Asclepias Fremonti, Torr.
435 Asclepias speciosa, Torr.
436 Asclepias Sullivantii, Engelm.
437 Asclepias verticillata, var. pumila, Gray.
438 Gomphocarpus tomentosus, Gray.

LOGANIACEÆ.

439 Polypremum procumbens, L.

GENTIANACEÆ.

440 Erythræa Muhlenbergii, Griseb.
441 Sabbatia campestris, Nutt.

POLEMONIACEÆ.

442 Gilia intertexta, Stend. (159).
443 Gilia squarrosa, Hook & Arn.

HYDROPHYLLACEÆ.

444 Ellisia Nyctelea, L. (160).
445 Emmenanthe lutea, Gray.
446 Phacelia tenacetifolia, Benth.

BORRAGINACEÆ.

447 Amsinckia intermedia, F. & M.
448 Amsinckia lycopsoides, Lehm.

449 Amsinckia spectabilis, F. & M.
450 Asperugo procumbens, L.
451 Cynoglossum officinale, L. (52).
452 Echinospermum Lappula, L. (54).
453 Echinospermum Redowskii, Lehm.
454 Echinospermum Redowskii, L.; var. cupulatum, Gray.
455 Echinospermum Redowskii, L.; var. occidentale, Watson (161).
456 Echinospermum Virginicum, Lehm. (162).
457 Echium vulgare, L. (53).
458 Heliotropium Curassavicum, L.
459 Heliotropium Indicum, L.
460 Krynitskia crassisepala, Gray.
461 Lithospermum arvense, L. (163).
462 Lithospermum canescens, Lehm.
463 Lithospermum officinale, L.
464 Lycopsis arvensis, L.
465 Onosmodium Carolinianum, DC.

CONVOLVULACEÆ.

466 Convolvulus arvensis, L. (55).
467 Convolvulus Californicus, Choisy.
468 Convolvulus incanus, Vahl.
469 Convolvulus luteolus, Gray.
470 Convolvulus sepium, L. (56).
471 Convolvulus sepium, L.; var. Americanus, Sims.
472 Convolvulus sepium, L.; var. repens, G.
473 Cuscuta epilinum, Weihe.
474 Cuscuta epithymum, Murray.
475 Cuscuta racemosa, Mart.
476 Cuscuta racemosa, M.; var. Chiliana, E.
477 Cuscuta salina, Engelm.
478 Ipomœa Bona-nox, L.
479 Ipomœa commutata, R. & Sch.
480 Ipomœa hederacea, Jacq. (164).
481 Ipomœa lacunosa, L.
482 Ipomœa pendurata, Meyer. (57).
483 Ipomœa purpurea, Lam.
484 Ipomœa Quamoclit, L.
485 Ipomœa tenuiloba, Torr.
486 Jacquemontia tamnifolia, Griseb.

SOLANACEÆ.

487 Datura metelodes, DC.
488 Datura Stramonium, L. (165).
489 Datura Tatula, L. (58).
490 Nicandra physaloides, Gærtn.
491 Nicotiana attenuata, Torr.
492 Petunia parviflora, Juss.
493 Physalis æquata, Jacq. f.
494 Physalis angulata, L.
495 Physalis lanceolata, Michx.
496 Physalis Virginiana, Mill. (59).
497 Physalis viscosa, L.
498 Solanum Carolinense, L. (60).
499 Solanum Douglasii, Dunal.
500 Solanum Dulcamara, L. (166).
501 Solanum elæagnifolium, Cav.
502 Solanum gracile, Link.
503 Solanum nigrum, L.
504 Solanum nigrum, L.; var. villosum, M.
505 Solanum rostratum, Dunal. (61).
506 Solanum triflorum, Nutt. (167).
507 Solanum Xanti, Gray.

SCROPHULARIACEÆ.

508 Antirrhinum Orontium, L.
509 Bartsia Odontites, Huds.
510 Gerardia divaricata, Chapm.
511 Linaria Canadensis, Dumont. (168).
512 Linaria vulgaris, Mill. (62).
513 Mimulus leteus, L.
514 Orthocarpus campestris, Benth.
515 Orthocarpus purpurascens, Benth.
516 Pentstemon lævigatus, Solander; var. Digitalis, Gray.
517 Rhinanthus Crista-galli, L.
518 Scoparis dulcis, L.
519 Scrophularia Californica, Cham.
520 Verbascum Blattaria, L. (63).
521 Verbascum Thapsus, L. (64).
522 Veronica arvensis, L.
523 Veronica officinalis, L. (169).
524 Veronica peregrina, L. (65).
525 Veronica serpyllifolia, L. (170).

OROBANCHACEÆ.

526 Aphyllon uniflorum, Gray.
527 Orobanche minor, L.
528 Orobanche ramosa, L. (66).

LENTABULACEÆ.

529 Utricularia subulata, L.

BIGNONIACEÆ.

530 Tecoma radicans, Juss. (171).

PEDALIACEÆ.

531 Martynia proboscidea, Glox.

VERBENACEÆ.

532 Callicarpa Americana, L.
533 Lippia lanceolata, Michx.
534 Verbena bracteosa, Michx. (172).
535 Verbena hastata, L. (173).
536 Verbena officinalis, L.
537 Verbena prostrata, R. Br.
538 Verbena stricta, Vent. (174).
539 Verbena urticæfolia, L. (175).

LABIATÆ.

540 Ajuga reptans, L.
541 Brunella vulgaris, L. (67).
542 Calamintha Nepeta, Link.
543 Galeopsis Tetrahit, L.
544 Hedeoma pulegioides, Pers. (176).
545 Hyptis radiata, Willd.
546 Isanthus cæruleus, Michx.
547 Lamium amplexicaule, L. (68).
548 Lamium purpureum, L.
549 Leonotis nepetæfolia, R. Br.
550 Leonurus Cardiaca, L. (69).
551 Lycopus Europæus, L.
552 Lycopus Virginicus, L.
553 Marrubium vulgare, L. (177).
554 Melissa officinalis, L.
555 Mentha Canadensis, L.
556 Mentha piperita, L.
557 Mentha veridis, L.
558 Monarda punctata, L. (178).
559 Nepeta Cataria, L. (70).
560 Nepeta Glechoma, Benth. (71)
561 Salvia lanceolata, Willd.
562 Stachys aspera, Michx.
563 Stachys bullata, Benth.
564 Stachys Floridana, Schl.
565 Trichostema oblongum, Benth.

PLANTAGINACEÆ.

566 Plantago lanceolata, L. (72).
567 Plantago major, L. (179).
568 Plantago mollis.
569 Plantago Patagonica, Jacq.
570 Plantago Rugelii, Decaisne. (73).
571 Plantago Virginica, L. (180).

NYCTAGINACEÆ.

572 Abronia micrantha, Torr.
573 Bœrhaavia erecta, L.
574 Oxybaphus hirsutus, Sweet.
575 Oxybaphus nyctagineus, Sweet.

ILLECEBRACEÆ.

576 Scleranthus annuus, L.

AMARANTACEÆ.

577 Acnida australis, Gray.
578 Acnida tamariscina, Gray.
579 Acnida tuberculata, Gray.
580 Alternanthera Achyrantha, R. Br.
581 Amarantus albus, L. (74).
582 Amarantus blitoides, Watson (75).
583 Amarantus chlorostachys, W. (76).
584 Amarantus hybridus, L.
585 Amarantus Palmeri, Watson.
586 Amarantus paniculatus, L. (181).
587 Amarantus retroflexus, L. (77).
588 Amarantus spinosus, L. (182).
589 Cladothrix lanugnosa, Nutt.
590 Froelichia Floridana, Moq.
591 Iresine celosioides, L.

CHENOPODIACEÆ.

592 Atriplex bracteosa, Watson.
593 Atriplex expansa, Watson.

594 Atriplex patula, L.
595 Atriplex patula, L.; var. hastata, G. (183).
596 Atriplex patula, L.; v. littoralis, G.
597 Chenopodium album, L. (78).
598 Chenopodium ablum, var. viride.
599 Chenopodium ambrosioides, L.(79).
600 Chenopodium ambrosioides, L.; var. anthelminticum, Gray.
601 Chenopodium Bonus-Henricus, L.
602 Chenopodium Botrys, L.
603 Chenopodium glaucum, L.
604 Chenopodium hybridum, L.
605 Chenopodium leptophyllum, Nutt.
606 Chenopodium leptophyllum, N.; var. oblongifolium, Watson.
607 Chenopodium murale, L.
608 Chenopodium polyspermum, L.
609 Chenopodium urbicum, L. (184).
610 Cycloloma platyphyllum, Moq. (185).
611 Eurotia lanata, Moq.
612 Salsola Kali, L.
613 Salsola Kali, L.; var. Tragus, A. DC. (186).

PHYTOLACCACEÆ.

614 Phytolacca decandra, L. (80).
615 Rivina humilis, L.

POLYGONACEÆ.

616 Chorizanthe pungens, Benth.
617 Eriogonum Albertianum, Torr.
618 Fagopyrum esculentum, Mœnch.
619 Lastarriæa Chilensis, Remy.
620 Polygonum acre, HBK.
621 Polygonum amphibium, L.
622 Polygonum aviculare, L. (81).
623 Polygonum Bistorta, L.
624 Polygonum cilinode, Michx.
625 Polygonum Convolvulus, L. (82).
626 Polygonum dumetorum, L.; var. scandens, Gray.
627 Polygonum erectum, L. (187).
628 Polygonum Hydropiper, L.
629 Polygonum incarnatum, Ell.
630 Polygonum Muhlenbergii, Watson.
631 Polygonum orientale, L.
632 Polygonum Pennsylvanicum, L. (83).
633 Polygonum Persicaria, L.
634 Rumex Acetosella, L. (84).
635 Rumex Britannicus, L.
636 Rumex conglomeratus, Murray.
637 Rumex crispus, L. (85).
638 Rumex hastatulus, Baldw.
639 Rumex hymenocepalus, Torr.
640 Rumex maritimus, L.
641 Rumex obtusifolius, L. (188).
642 Rumex pulcher, L.
643 Rumex salicifolius, Weinm.
644 Rumex sanguineus, L.
645 Rumex verticillatus, L.

SANTALACEÆ.

646 Comandra pallida, A. DC.

EUPHORBICEÆ.

647 Acalypha Caroliniana, Walt.
648 Acalypha Virginica, L. (86).
649 Croton argyranthemus, Michx.
650 Croton capitatus, Michx.
651 Croton monanthogynus, Michx.
652 Crotonopsis linearis, Michx.
653 Eremocrapus setigerus, Benth.
654 Euphorbia albomarginata, T. & G.
655 Euphorbia corollata, L. (189).
656 Euphorbia Cyparissias, L. (190).
657 Euphorbia dentata, Michx.
658 Euphorbia Helioscopia, L.
659 Euphorbia hypericifolia, L.
660 Euphorbia Lathyris, L.
661 Euphorbia maculata, L. (88).
662 Euphorbia marginata, Pursh. (191).
663 Euphorbia ocellata, Dur. & Hilg.
664 Euphorbia Preslii, Guss. (87).
665 Euphorbia serpens, HBK.
666 Euphorbia serpyllifolia, Pers.
667 Jatropha urens, L.; var. stimulosa, M.
668 Stillingia sylvatica, L.

URTICACEÆ.

669 Cannabis sativa, L.
670 Parietaria Pennsylvanica, Muhl.
671 Pilea pumila, Gray.
672 Urtica dioica, L.
673 Urtica gracilis, Ait.
674 Urtica holosericea, Nutt.
675 Urtica urens, L.
676 Comptonia asplenifolia, Ait.

CAPULIFERÆ.

677 Alnus serrulata, Willd.

SALICACEÆ.

678 Salix discolor, Muhl.
679 Salix humilis, Muhl.
680 Salix lucida, Muhl.

CONIFERÆ.

681 Juniperus communis, L.

SCITAMINEÆ.

682 Canna flaccida, Roscoe.

HÆMODORACEÆ.

683 Lachanthes tinctoria, Ell.
684 Lophiola aurea, Ker.

IRIDACEÆ.

685 Iris versicolor, L.
686 Sisyrinchium bellum, Watson.

LILIACEÆ.

687 Allium Canadense, Kalm.
688 Allium vineale, L. (89).
689 Asparagus officinalis, L.
690 Calochortus invenustus, Greene.
691 Smilax glauca, Walt.
692 Smilax rotundifolia, L.
693 Veratrum viride, Ait.
694 Yucca angustifolia, Pursh.
695 Yucca filamentosa, L.

PONTEDERIACEÆ.

696 Pontederia cordata, L.

COMMELINACEÆ.

697 Commelina hirtella, Vahl.
698 Commelina Virginica, L. (192).
699 Tradescantia rosea, Vent.
700 Tradescantia Virginica, L.

JUNCACEÆ.

701 Juncus bufonius, L.
702 Juncus effusus, L.
703 Juncus tenuis, Willd.

ARACEÆ.

704 Symplocarpus fœtidus, Salisb.

CYPERACEÆ.

705 Cyperus Baldwinii, Torr.
706 Cyperus compressus, L.
707 Cyperus cylindricus, Chapm.
708 Cyperus esculentus, L. (90).
709 Cyperus filiformis, Swartz.
710 Cyperus ovularis, Torr.
711 Cyperus polystachyus, Rottb.
712 Cyperus rotundus, L.
713 Cyperus Schweinitzii, Torr.
714 Cyperus strigosus, L.
715 Eleocharis capitata, R. Br.
716 Eleocharis tenuis, Sch.
717 Fimbristylis autumnalis, R. & S.
718 Fimbristylis laxa, Vahl.
719 Scleria oligantha, Ell.
720 Scleria Torreyana, Walpers.

GRAMINEÆ.

721 Agropyrum repens, L. (91).
722 Alopecurus geniculatus, L.
723 Alopecurus geniculatus, L.; var. aristulatus, Munro.
724 Alopecurus pratensis, L.
725 Andropogon scoparius, Michx.
726 Andropogon tener, Kunth.
727 Andropogon Virginicus, L.

728 Aristida dichotoma, L.
729 Aristida gracilis, Ell.
730 Aristida lanata, Poir.
731 Aristida purpurascens, Poir,
732 Aristida stricta, Michx.
733 Avena fatua, L. (193).
734 Briza media, L.
735 Bromus mollis, L.
736 Bromus racemosus, L.
737 Bromus secalinus, L. (92).
738 Bromus sterilis, L.
739 Bromus tectorum, L. (93).
740 Cenchrus echinatus, L.
741 Cenchrus Myosuroides, HBK.
742 Cenchrus tribuloides, L. (94).
743 Chamæraphis glaucus, L. (99).
744 Chamæraphis viridis, L. (100).
745 Chamæraphis verticillatus. (L). Britt. (194).
746 Cynodon Dactylon, Pers.
747 Danthonia spicata, Beauv.
748 Distichlis maritima, Raf.
749 Eleusine Indica, Gærtn. (95).
750 Eleusine Ægyptiaca, Pers.
751 Eragrostis Brownei, Nees.
752 Eragrostis capillaris, L.
753 Eragrostis ciliaris, Link.
754 Eragrostis major, Host. (195).
755 Eragrostis minor, Host.
756 Eragrostis pectinacea, Gray.
757 Eragrostis Purshii, Schrad.
758 Festuca Myurus, L.
759 Gymnopogon racemosus, Beauv.
760 Heteropogon acuminatus, Trin.
761 Hierochloa borealis, R. & S.
762 Hierochloa odorata, L. Wahl. (196).
763 Hordeum jubatum, L. (197).
764 Hordeum murinum, L.
765 Hordeum nodosun, L.
766 Leptochloa mucronata, Kunth.
767 Lolium perenne, L.
768 Lolium temulentum, L
769 Muhlenbergia diffusa, Schreb.
770 Muhlenbergia Mexicana, Trin.
771 Munroe squarrosa, Torr.
772 Panicum agrostoides, Muhl.
773 Panicum anceps, Michx.
774 Panicum capillare, L. (96).
775 Panicum commutatum, Schultz.
776 Panicum consanguineum, Kunth.
777 Panicum Crus-galli, L. (97).
778 Panicum Curtisii, Chapm.
779 Panicum dichotomum, L.
780 Panicum filiforme, L.
781 Panicum gibbum, Ell.
782 Panicum glabrum, Gaud.
783 Panicum hians, Ell.
784 Panicum miliaceum, L.
785 Panicum nitidum, Lam.
786 Panicum platyphyllum, Munro.
787 Panicum proliferum, Lam.
788 Panicum sanguinale, L. (98).
789 Panicum scoparium, Lam.
790 Panicum serotinum, Trin.
791 Panicum Texanum, Buckl.
792 Paspalium ciliatifolium, Michx.
793 Paspalium distichum, L.
794 Paspalium læve, Michx., Ell.
795 Paspalium platycaule, Poir.
796 Paspalium purpurascens, Ell.
797 Paspalium racemulosum, Nutt.
798 Paspalium setaceum, Michx.
799 Paspalium Walterianum, Schultes.
800 Poa annua, L. (198).
801 Poa compressa, L.
802 Poa pratensis, L.
803 Polypogon Monspeliensis, Desf.
804 Sorghum halepense, Pers.
805 Sporobolus Floridanus, Chapm.
806 Sporobolus Indicus, R. Br.
807 Sporobolus junceus, Kunth.
808 Sporobolus vaginæflorus, Vasey.
809 Stipa spartea, Trin. (199).

EQUISITACEÆ.

810 Equisetum arvense, L.
811 Equisetum heimale, L.
812 Equisetum sylvaticum, L. (200).

FILICES.

813 Osmunda cinnamomea, L.
814 Osmunda Claytoniana, L.
815 Osmunda regalis, L.
816 Onoclea sensibilis, L.
817 Pteris aquilina, L.

LIST OF INSTITUTIONS SUPPLIED WITH WEED HERBARIA.

Below is given, by States, the institutions which have procured the weeds placed opposite their names.

	First Century.	Second Century.	Century of Seeds.
Alabama, Polytechnic Institute, Auburn	1	1	1
Arizona Experiment Station, Tucson	1	1	1
Arkansas " " Fayetteville	1	......	1
California " " Berkeley	1	......	......
Colorado " " Fort Collins	1	1	1
Delaware " " Newark	1	1	1
Florida " " Lake City	1	......	......
Georgia " " Experiment	1	......	......
Illinois University, Champaign	1	1	......
" Northwestern University, Evanston	1	1	1
Indiana Experiment Station, Lafayette	1	1	1
Iowa " " Ames	1	1	1
Kansas " " Manhattan	1	1	1
Louisiana " " Baton Rouge	1	1	1
Maine " " Orono	1	1	......
Maryland " " College Park	1	1	1
Massachusetts, Hatch Experiment Station, Amherst	1	......	......
" Experiment Station, Amherst	......	......	1
Michigan " " Agricultural College	1	1	1
" University, Ann Arbor	1	1	1
Minnesota Experiment Station, St. Anthony Park	1	1	1
Mississippi " " Agricultural College	......	......	......
Missouri " " Columbia	1	1	1
Nebraska " " Lincoln	1	1	1
Nevada " " Reno	1	......	......
New Hampshire " " Hanover	1	......	......
New York State " " Geneva	1	1	1
" " Cornell Experiment Station, Ithaca	1	1	1
" " " University, Ithaca	1	1	1
" " Columbia College, New York	1	1	......
N. Carolina Experiment Station, Raleigh	1	1	1
N. Dakota " " Fargo	1	......	......
Ohio " " Columbus	1	......	......
Oklahoma " " Stillwater	1	1	1
Oregon " " Corvallis	1	......	......
Pennsylvania " " State College	1	1	1
Rhode Island " " Kingston	1	1	......
S. Carolina " " Fort Hill	1	......	......
S. Dakota " " Brookings	......	1	1
Tennessee " " Knoxville	1	1	1
Texas " " College Station	1	......	1
Utah " " Logan	1	1	1
Vermont " " Burlington	1	1	1
Virginia " " Blackburg	1	1	1
W. Virginia " " Morgantown	1	1	1
Wisconsin " " Madison	1	1	1
Wyoming " " Laramie	1	1	......
Total	44	34	32

Several seed-houses have taken sets of the seeds.

Illustrated Lecture Upon Weeds.

In connection with the World's Columbian Exposition a lantern lecture was prepared at the request of the Director of the Office of Experiment Stations. Below is the outline of this lecture:

Introduction.—Crop-growers almost everywhere experience great losses from the presence of weeds. In the aggregate this loss is very great, doubtlessly amounting annually to millions of dollars. Knowledge is the best weapon with which to meet this enemy.

Definition.—A weed is a plant growing out of place; that is, interfering with the development of another plant which under the circumstances is of more importance to the grower. Nearly all plants may be weeds, but there are only a few hundred of them that are usually such. The number of plants that are always "out of place" is only a few score. The term "weed" is applied in particular to plants which are of considerable size, and not to the microscopic kinds, as rots, smuts, mildews, moulds and various blights.

Many names of common weed plants may be mentioned, all of which suggest pests of the farm and garden. Thus there are the bindweed, blueweed, bur-grass, chickweed, cockle, daisy, doorweed, hawkweed, hogweed, horseweed, jimsonweed, mayweed, mustard, pigweed, purslane, ragweed, smartweed, stickweed, thistle and many others.

The Slides.—In the first slide is shown six quite different species of weed, namely, one of the mustard, the pursley, the butter-print, a ragweed, the jimsonweed and a pigweed. These are all bad enemies to the crop-grower and common to all.

There are several weeds among the grasses, and the second slide shows four of them, all from photographs of the plants themselves. The quack-grass is the most troublesome of all because it takes a firm hold of the soil, smothers out other plants and spreads underground by subterranean stems, making it difficult to eradicate. Plowing and harrowing a field partially infested may spread the pest widely. Only the most thorough culture will suffice. A greater nuisance in some respects is the bur-grass. This, while growing wild most frequently in sandy places, may occupy cultivated ground. One of the most objectionable features of this plant is the burs, which are covered with many sharp spines, much to the terror of the small boy.

This spinose covering to the seed is a good illustration of the provision of nature for the dispersion of seeds, a point to be considered later in the lecture.

In the next picture is seen a specimen of a weed that is spreading rapidly in the West; it is called the Russian thistle. It comes from the seed each year and therefore is an annual weed, growing six inches to three feet in height, branching profusely, and thus forming a dense bush-like top. The stiff branches bear multitudes of sharp spines, making the plant particularly disagreeable to horses and other animals, not to mention the farmer who is obliged to handle grain infested with the prickly pest. In many ways it is worse than any thistle.

There is little doubt that this vile weed was introduced into South Dakota about fifteen years ago in flaxseed imported from Europe, and soon partook of "the conquering spirit of the West." It seeds abundantly and as a tumble-weed, with ample provision for the dissemination of the offspring. In places where, only a few years ago, there were only scattered plants, the whole land is filled with the thistles. It is now troublesome over fully 20,000 square miles, inflicting a loss of $2,000,000 annually.

The United States Government, recognizing the magnitude of this recent enemy, has published a bulletin upon the subject, closing with the following recommendations:

"Place a Russian thistle in each school-house so that the pupils may become familiar with it, and teach them to kill it whenevere they find it as they would kill a rattlesnake.

"Permit no Russian thistle to go to seed. The plant is an annual; the seeds are evidently short lived. Hence, if no plants are permitted to go to seed for two years the weed will, in all probability, be exterminated.

"Let no one break up more land than he can take care of or more than he can properly cultivate.

"Let each farmer keep down all the weeds on his own farm and then insist that his neighbor do likewise.

"A little careful legislation that will touch up the careless farmer, the non-resident landowner and the railroad companies would aid considerably in the solution of the question.

"Be careful that all of the seed sown be as pure and clean as the modern fanning-mill can make it. Use special care in regard to flaxseed and millet, or any of the smaller and lighter seeds."

In slide 5 is shown another comparatively new comer into the ranks of American weeds. The golden hawkweed was first introduced

nto this country as an ornamental plant, its rich orange blooms being emarkably attractive. The record of its most rapid spreading hroughout the New England and Eastern States in the last three ears is largely due to the conspicuous character of its flower clusters. t is not everywhere over the above-named area, but here and there nd to be expected anywhere. The seeds, like many other of the andelion family (Compositæ), are provided with plumes, fine and eathery, by means of which long flights may be taken. After the lant has once established itself, it is able to spread with much success y means of underground branches, so that from a single root there nay soon develop a whole colony of stems and plants. This strong endency to propagate below the surface, together with the provision or seed distribution, insures this bitter weed a great field for injury o the American farmer. It is not the only instance in which beauty n a plant has ultimately caused trouble. The toadflax, now occupyng large areas in various parts of the country to the exclusion of seful plants, was introduced as an ornamental plant. While it may e handsome in the abstract, its habits are such that the crop-grower vould gladly dispense with its attractions for the relief the eradicaion of the pest would bring.

Weeds, as a rule, have something about them that is attractive. They are not altogether bad, as a rule. Even the Russian thistle nakes good forage for sheep when it is young and tender.

The next weed to be shown in like manner is a forage plant of no mall importance and only becomes a nuisance when maturing its ruit. This stork's-bill or pin-grass, as the names suggest, has the eeds provided with long slender awns by means of which the seeds enetrate the wool of the passing sheep. By this means the plant as spread from California, where it abounds, to many distant parts f the United States. Wool, for example, carried from the far West o the Eastern States and there manufactured, takes with it the adhering seeds, and these being separated at the carding mills find their way lown streams and spread into the surrounding country. It is to be resumed that the awn is designed to assist in the burial of the seed, or by its twisting and untwisting, due to the differences in amount f moisture, the seed is worked down into the soil. Several kinds f plants have this provision for the burial of the seeds, and so great s it in the porcupine grasses (*Stipa*, sp.) that they will penetrate not nly the wool and hair of animals but the skin and flesh, thus causing

great distress and even death. Such plants are even more savage than the bur-grass, which confines itself to the exterior, the seed not reaching the vitals. It is remarkable to what extent the idea of the distribution of seeds has gone in many instances, particularly with weeds. There are plants that, seemingly harmless to all appearances have a very remarkable influence upon the animals which feed upon them. Such, for example, are the so-called "Loco Weeds."

There are many species that possess the power of producing a derangement in animals that for the lack of a better term has been called "craziness." The suffering from locoism has been great in some regions, particularly in the Prairie States, and the malady has been an obscure subject to the veterinarians for many years. The trouble has been traced to several plants in the pea family (Leguminoseæ), among which are the two shown in picture No. 6. The "Loco Weeds" proper are shared in particular by the two genera Oxytropus and Astragalus. The "Rattlebox," so named for the mature seeds becoming loose in the pod, is found over a wider region than the loco weeds, it being common in the Eastern States. In the ordinary sense of weeds—that is, as occupying cultivated land to the exclusion of crops—the loco plants do not of course take a high rank.

In the systematic study of weeds a scale of points may be made out as shown in the next picture (No. 7). On a scale of a hundred five points are assigned to each of the twenty subjects. Thus the purslane is high in seeding capacity (5), while the separation of that seed is easy (1). There is no special provision for dissemination (1) while with the Canada thistle, it is ample (5). Root and stem propagation for purslane is very low (0), while for the thistle it is at the highest (5), and the same difference is shown for obnoxious qualities The ideal weed would have a hundred points against it, while the worst given in the table ranks seventy-four, and the lowest, that is least objectionable, the toadflax, is only thirty-one. This is probably not a high enough rating for the pest. While time will not permit a full explanation of the scale of points, it is shown that by such a plan the chief features of a weed and their comparative demerits are recognized.

Weeds as to their length of life are divided into annuals, biennials and perennials. The annuals coming from seed live for a year or less and die. In the eradication of all such species the chief point is to

estroy the weeds before they have matured seed, and the earlier this done the better. Weeds that live for more than one year need to e known more intimately as to their habits, both above and below he surface of the soil. The next set of pictures upon the screen No. 8) shows the appearance of twenty-nine kinds of our common eeds, as seen in early spring before they begin to send up flower alks. Each one has a form peculiar to itself, and is easily recognized fter a little attention has been given to the matter. It is while the eeds are in this "rosette" condition that they can be the most easily prooted, and with the least interference to the crop.

(It may be interesting to state that the picture is made from a hotograph of a set of fresh specimens laid in natural position upon a arge table, the camera being above and adjusted vertically.)

The next picture (No. 9) shows us the root system of fifteen species f our worst weeds, worst in large part because of the great tap roots which they possess.

Without stopping to name all the species from wild parsnip in No. to the garden mallow in No. 15, it is only necessary to say that such eeds, when once firmly anchored in the soil, are removed with difficulty. If cut down to the ground they send up several sprouts, and ven when overturned and cut to pieces by the implements of culture will often survive, the fragments ofttimes making new and vigorous lants.

In the next view is shown two specimens of roots of the wild norning-glory, sometimes called "Man-of-the-earth," on account of the ize and shape of the roots. While the portion above ground s a comparatively slender vine that needs some support to twine round, the root system becomes enormous and may sometimes weigh score or more pounds, extending down for several feet. It is a day's task to remove a large root, and therefore when a field is badly nfested with this pest the only hope is to destroy the plants by preventing the roots from gaining any support from leaves above ground. This is a member of the sweet potato family, which contains several pecies that are miserable pests, some of them being the genuine bindweeds.

The root systems of weeds are continued in the next (No. 11) picture, where are shown two plants, namely, the bouncing bet and sorrel. In both the plant spreads rapidly, so that there are many ndividual stems arising from the same system of roots. A whole

patch of bouncing bet plants, several feet across, is all connected, as shown in the picture, which is from a photograph of a portion of a plant with its underground part removed in early spring, when the young shoots, indistinctly shown, were just starting into growth. The picture shows a plant with its many tufts of leaves, the whole arranged as found in the soil. Cultivation, unless thoroughly done, only assists in the propagation of such weeds.

In No. 12 we pass to another class of plant pests, namely, the parasites. There are many plants that have no means of support within themselves, and instead of robbing the soil, as is the practice of ordinary weeds, they prey directly upon the crop itself. The one shown in the picture is a dodder that infests the clover. The dodder seeds may be either among that of the clover when the latter is sown, or previously in the soil. Soon after germination the young dodder plant attaches itself to the clover stem and draws food from it through its penetrating roots. Because thus parasitic, it requires no leaves or other green parts, and consequently remains pale and leafless, abounding in small flower clusters and maturing, finally, a multitude of seeds. Dodders are of various kinds and infest many crops, the clover and flax being the two that most frequently suffer. Plants infested with the dodder should be destroyed to prevent the parasite from seeding.

A second kind of parasite is known as the broom-rape. This is particularly destructive to the tobacco and hemp in some parts of our country. It was doubtless introduced in imported seed, and seeding has stocked some fields with the germs of the enemy. The picture shows a plant in flower and fruit, and also gives the history of its development upon the host. Attaching itself to a root, the enemy grows, first as a nodule, until it partially exhausts the hemp or tobacco plant, and out of the substance thus stolen makes a vast number of seeds. The methods to be observed with these parasitic weeds are somewhat different from those with soil weeds. But so far as the seeding is concerned, it is evident that both the pale thief and the crop plant upon which it is fastened must both go together for the sake of preventing the seeding of the pest.

Weeds are to be eradicated in various ways, as previously pointed out. Clean culture must conquer them, provided the new supplies of seed are not introduced. The best way is to kill a weed when it is small. When it gets full-sized and deeply-rooted, either the whole root system must be removed or killed in place. For the latter all

sorts of substances have been employed. To put on the screen the leading weed-killers would mean the passing in review of all the implements for cultivating the soil from the garden hoe and "weeder" up to the harrow and steam plow.

Pure seeds cannot be too strongly insisted upon in this connection. The ease with which foul stuff can be present in crop seed is illustrated in the next picture (No. 14). This shows a group of timothy seed in the center, with the seeds of eight kinds of miserable weeds around it. They are of crab-grass, foxtails, two kinds of each, the yarrow, chamomile, ox-eye daisy and Canada thistle. This is a bad lot of weeds, the seeds of which readily pass with the timothy.

In like manner the red clover seed is shown in picture 15 surrounded by ten of its enemies, the seeds of which might be mistaken for it. They are in the order of their position: Healall, bouncing bet, dodder, white and yellow melilot, nonesuch, narrow-leaved plantain, pepper-grass and bladder ketmia. Without the most careful inspection, these and several other kinds of weed seeds may be sown with the clover. Where the possibilities are so great for foul stuff being present it is wise for all who purchase seed to be upon their guard Seedmen may have the best of intentions and yet deal in weed seeds to a considerable extent. It is therefore well for the experiment stations to stand ready to inspect seeds for their purity as well as vital power. To this end a set of weed seeds shown in picture 16 has been placed within the easy reach of each experiment station. This gives one hundred kinds of weed seeds, and includes those that would be likely to occur in commercial seeds. By having these authentic specimens, the difficulty of determining the exact nature of the foul stuff is greatly reduced. It may be said in passing that along with these seeds there has been sent a set of mounted and fully-labeled weeds to the number of two hundred species. Therefore, not only the seeds, but the nature of the plant producing the same, can be readily determined.

But weed seeds do not always get into the soil by being sown there with the crop. As before suggested, they have many means of dispersion. Man plays his role successfully in seed distribution and so do the wind and the waves, the passing animals and the birds. Many weed seeds are provided with wings or airy tufts of hair which serve as balloons for long and lofty flights. The thistle which a neighbor tolerates may seed down the whole region around.

The next picture (No. 17) shows a few seeds of weeds that are provided with means for holding fast to the exterior of animals, and include the cockleburs, burdocks, stickseeds, pitchforks and several others with expressive names. The advantage of these provisions in nature for the transportation of seeds goes without further explanation.

Last, and bearing directly upon the subject of plant distribution, is shown a view on the prairie of the Russian thistle in the role of tumble-weed. This new and vile pest has been previously mentioned. While we have hundreds of miserable weeds, this one, now so much dreaded in the West, seems to eclipse them all. The upper picture may seem overdrawn, showing the large balls of the united uprooted weeds frightening even the wild animals, but the fact remains that weeds do travel in many ways besides in sacks of seeds, and if we do not use all means to keep them down they will possess the earth, driving out the thriftless farmer as the antelopes flee from the Russian thistle.

Potatoes by the Direct Method.

Early in June, specimens of seed potatoes were sent to the Experiment Station with the complaint that they failed to produce plants. Small potatoes of the size and shape of pullets' eggs had grown directly from the eyes of some of these pieces and with their formation development had ceased.

Shortly after, the writer made a visit to the field from which the peculiar potatoes had been dug. The field in question is in the midst of the finest potato-growing section of New Jersey, where, as the owner said, the Irish potato is the only crop there is "any money in." It was found that about ten per cent. of the "seed" had failed, and of course the field presented a very "ragged" appearance. This was a full month after planting and ordinary hills were nearly a foot high. Many blank places were dug into and a score and more of seed pieces found that had one or more new potatoes an inch or so from the "seed" and nothing more. (See Figure 2.) As the seed was cut by a machine there were some "blind" pieces, which accounted for a small percentage of the failures, but the greater number was due to the strange development above mentioned.

At the same time many plants were found that had either recently roken through the ground or showed a pale, feeble growth of stem nd foliage. Upon examination, these showed that there had been a ormation of a secondary tuber, and from the upper free end of this he sprout had developed in the slow and unsatisfactory manner indi-ated. This form is shown in Figure 3.

A third form of abnormal growth (Figure 4) was seen among these lants that showed a sickly development. The second form is seen to e a further development of the first form, namely, the new tubers,

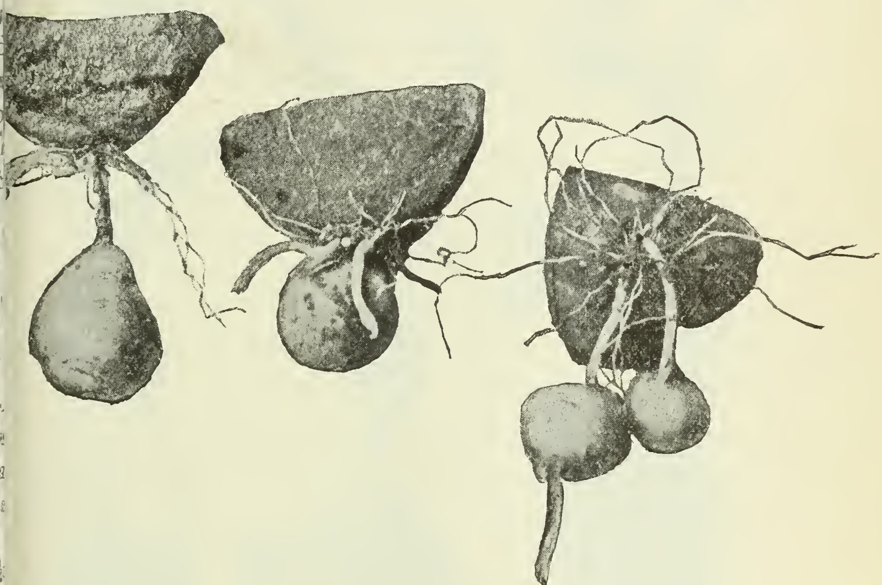


Fig. 2.

New potatoes directly from the seed.

nstead of being the culmination of growth, became the starting point, o to speak, of the upright leafy stems. In the third form there is he formation of both of the secondary tubers direct from the seed" and also an attempt to send up shoots of the ordinary sort. he reason for a failure in each and all of these instances is, mani-estly, because of the entire or partial exhaustion of the seed from the ansfer of its substance to the secondary tubers.

It may be remarked that the trouble, as here found, was confined one variety of potato of great popularity and grown largely in the

section visited. While not able to visit other farms, it was assure me that many other growers had the same "ragged" fields, and tha the failure was due to the same development and was confined to th same variety, namely, "Rural, No. 2."

The formation of new potatoes directly from old ones is no brought forward as any novel occurrence, for this process has bee

Fig. 3.

Direct new potatoes producing tops.

resorted to by English gardeners to produce a new crop in wint To obtain these fresh potatoes, old tubers of the previous yea growth are kept through the summer in a cool place and all sprou removed as they appear. These potatoes, in autumn, are placed boxes of sand and set where the temperature is maintained at six

degrees. After three months a crop of new potatoes will have formed from the old ones without the aid of stems and leaves.

The writer has likewise seen potatoes which had produced smaller ones within themselves, a freak not so very difficult to account for.

Fig. 4.

Both direct potatoes and ordinary tops.

The eye forms a new tuber at its base, the eye or bud being, so to speak, a minute potato plant, and the surrounding tuber the soil in which the growing potato develops. Usually, they are outside the skin, but, the tissue being soft and the skin tough, if the beginning

takes place within the potato, it may there continue until the skin may be broken by the pressure. It is possible that the conditions for growth may be more favorable within than outside of a tuber.

The potato plant forms its starch in the green parts, transfers this to the tuber under ground, which is a swollen stem bearing several points for further growth, the eyes, into which the substance of the tuber may be drawn if the eyes develop. This growth may be into a stem many feet in length under the conditions which obtain in a warm, dark room. If in contact with the soil, roots most usually form near the base of the young stem, and, rising to the air and sunshine, they soon develop a leafy stem, and an independent potato plant results. Instead of a long, sickly, weak stem in the darkness, or the leafy, well-rooted stem or normal form, it is not beyond expectation that other conditions should produce tubers directly without length of stem or profusion of foliage.

Doctor F. M. Hexamer, editor of the "American Agriculturist," upon my calling his attention to the subject, recollected that many years ago he saw seeds behave in the same way. The potatoes were planted very late and had been sprouted several times before planting, consequently the vitality of the tubers was greatly diminished. The conditions of the soil and weather at the time were unfavorable to the normal growth of the potato, consequently nature made a final and extraordinary effort to perpetuate its kind by utilizing all the vitality of the seed to produce a tuber that could develop a normal plant the following season. In the present instance many of those young tubers started into growth at once.

At the time when the potatoes were being investigated, letters or copies of a weather bulletin containing a brief description of the abnormal growth were addressed to a large number of persons who, from the standpoint of advanced agriculture or vegetable physiology would be most apt to know of the trouble and the reason for the same. But few replies were received; some of these from those who had not previously known of the peculiar growth, and no one offering a full explanation. One authority upon potato-growing in this country writes: "I am entirely at a loss to understand what was the matter with those potatoes. I have never had any experience in that direction."

A professor of botany writes, "Your funny New Jersey potatoe

are very interesting," and then entered the field of speculation, and wrote, among other things, "Maybe it was low temperature. I rather think it was deficient light. They are parasitic, chlorophylless shoots. Physiologically, they are parasitic growth—self-parasitism." He also reported that upon inquiry a potato-grower in his vicinity has found similar tubers in the bin.

The thought in the mind of the potato-grower whose field was visited, that it was probably a varietal peculiarity, in the light of the above reports from others, is not tenable. At least it cannot be confined to the variety that was behaving badly with him.

From what can be drawn from the practice of the foreign truckers who forced new potatoes to form without stem and leaves for commercial purposes, and with the aid of the suggestions of our own growers and vegetable physiologists generally, it would appear that one or more of several conditions may have induced the formation of the young tubers.

It would seem that anything that should weaken the seed before it has been planted might lead to the failure of the plant in the manner complained of. This might be immaturity of the seed or unfavorable surroundings after they had become matured; if frosted, for example, or if kept where they had sufficient warmth to begin to grow. Tubers that had their sprouts removed might be induced to take the shortest path toward reproduction, and should the sprouts have been long, the exhaustion would have been greater, and the tendency to form tubers increased accordingly.

It is possible that potatoes in no way abnormal might be induced to form secondary tubers through the unusual conditions that sometimes obtain after planting. Moisture is to be assumed as one of the conditions favoring the normal growth of young potato sprouts. Should this be absent, the seed in the soil, stimulated by the warmth, might push its eyes, and there being no chance for the tender roots to succeed, few or none would be formed in the dry earth and a secondary tuber result.

Both weakened seed and unfavorable conditions in the field may combine to bring about a failure to produce healthy plants.

Unlike seeds, the piece of the tuber when planted has no embryo to be unfolded, but instead it is a stem, or portion of one, surcharged with substance for the growth of the side buds (eyes) into whatever

structure conditions may determine. As before stated, if in darkness with light from one point, as a small window, the stem may be abnormally long, pale and weak. Where moisture and earth abound, the normal, deeply-rooted, leafy-stemmed plant results. Between these two extremes of perfect respose and the active reproductive plant in the rich field, there are many gradations, one of which, and the most exceptional, has been here touched upon in three of its phases, namely, with secondary tubers only, secondary tubers with struggling, leafy stems from them, and secondary tubers and struggling, leafy stems from the same piece. A certain variety may be more inclined to develop these tubers than other sorts, possibly from some inherited tendency to so behave, but more probably because of lack of vitality inherited, or because prone, we will say, to sprout early in the spring, and the secondary sprouts to form tubers after planting. The case ought not to lose interest because not entirely disposed of.

The Solandi Process of Sun-Printing.

A quick and cheap method of recording the appearance of various diseases of plants was sought for during the year and the following method was developed:

The process consists, briefly, in exposing the subject, necessarily somewhat translucent, to the sunlight in a printing frame in common use by photographers, with a sheet of sensitized paper back of the subject, in the same manner as a print is taken from a negative of the ordinary sort. The paper which has thus far proved the most successful has been the "American Aristotype," for the manner of using which full directions accompany the same, and will not be entered into here.

The sun-print thus obtained after it has been toned becomes the negative from which the positive picture is printed. To do this quickly and to the best advantage, the negative print is placed back downward in a dish containing a thin layer of common kerosene, care being taken to wipe it free from all surface oil after being re-

oved. This negative saturated with the kerosene is placed face ward upon a clean plate of glass in the printing frame and upon it fresh sheet of the "Aristo" paper is laid and clamped in place. he printing of the positive in the full sunlight is the work of only half minute or so, but better results are often obtained by a slower inting in diffused light; in fact, the same rules hold good for this rm of printing as for that of ordinary negatives by means of the mera.

The process of toning is the same for the positive as the negative, id in the same bath an indefinite number of either or both may be idergoing the process at the same time.

The fact that the object needs to be partially translucent, places nitations upon the application of the process, as likewise does the ability to enlarge or reduce the size of the object. There are, hower, very many instances when the process may be employed with a nsiderable degree of satisfaction, and in some cases it is possible to ing out points of structure not recorded by the ordinary methods of iotography. The principle is different, for in the one reflected light ordinarily employed and a surface picture is obtained; but by the landi (Sol and I) process the picture is obtained by the unequal ansmission of light through the different parts of the object. For ample, a leaf variegation may be confined to the surface cells and is sily caught by photography, but not in the sun-print. On the other ind, the variegation may be more than skin deep and the results ay be reversed by the two methods. Any object that is naturally in enough to permit the passage of light, even feebly, may become subject of sun-printing, the time of exposure being correspondingly creased. Thick leaves like the orange, through which but little ght seems to pass, will give good prints after an exposure of a few urs, while ordinary leaves, as those of the maple, are quickly done. ie orange leaf is a case in point where the sun-print reveals in a iking manner the number, size, position, etc., of the oil glands, all which are not secured in the common photograph. Anything like e venation of leaves is of course secured with full details by the ocess of transmitted light. In like manner many good records can made of the various rusts, leaf spots and blights upon foliage, and cellent pictures of wood are secured when thin sections in any direcon of the grain are employed.

In the case of leaves, the negative may be secured from the freshly-gathered specimens without any preparation; but dry objects from the herbarium work fully as well and often better when they are first saturated with the kerosene, in the same way as for the negative sun-prints, and wiped free of excess of oil before being placed in the frame.

It was my hope to show to the readers of the report actual specimens of the work done by the Solandi process, but it may be even better to present two engravings, as they will indicate that the sun-prints may be used for illustrations in printed articles with a fair degree of success. Figure 5 shows a leaf of the common hollyhock

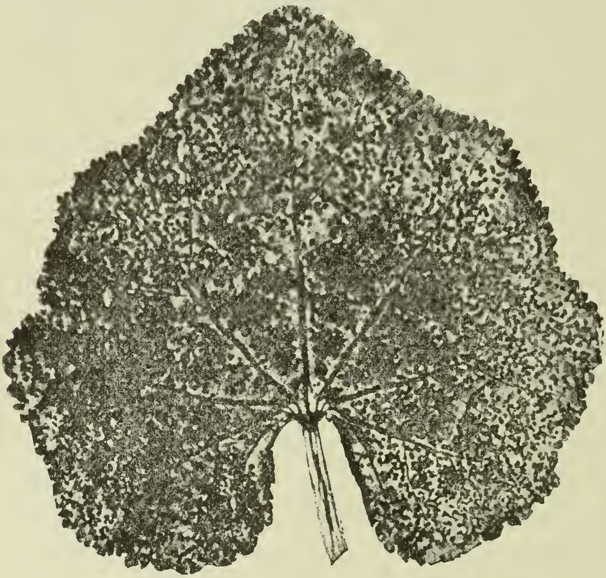


Fig. 5.

Holyhock leaf showing rust fungus.

badly infested with the rust (*Puccinia malvacearum*, Mont.); th object being chosen as one that is a fair average as pathological speci mens go, there being no marked light and dark patches as seen from a surface view. The transmitted light brings out the sori of th Puccinia in sufficient prominence to make them fairly distinct an much better than could have been done by ordinary photograph; The second illustration (Figure 6) is another leaf (Polygonatum), bu

of a widely-different class from the mallow, in which the veining is prominent and the work of a leaf miner is illustrated, as also the presence of a blight (*Phyllostica cruenta*, Fr.) following in the wake of the ruin caused by the insect.

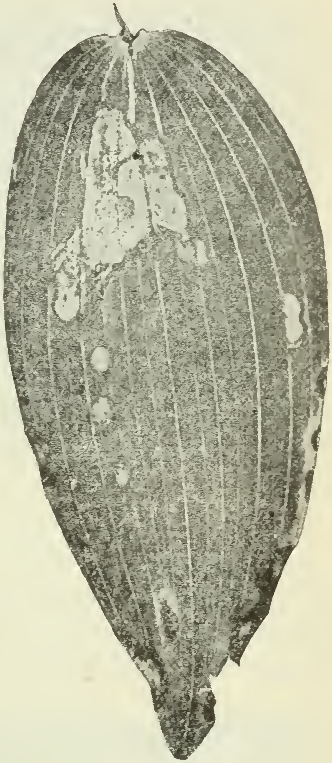


Fig. 6.
Polygonatum leaf showing insect and fungus work.

By this process there is no opportunity for any minifying or magnifying of the object, and each detail is as exact, as to size, location, etc., as possible. But the strongest points in favor of the process, aside from the merits of the results, are the ease with which the picture may be taken by any one, and the remarkable cheapness, for no camera or dark room is needed, and the whole time from the first exposure of the object until the positive is finished may not be more than three hours.

There is nothing new in sun-printing, for Professor Kellerman and other American botanists have employed it. The chief point to be urged is the use of the clarifying agent, kerosene, for subjects when they are dry and for negative prints. This not only diminishes the time of exposure tenfold and more, but remarkably sharpens the details of the positive picture. Other engravings made from sun-prints by the Solandi process may be found elsewhere in this report, as, for example, those illustrating two hollyhock diseases, dracæna leaf blight, orchid flower spot, etc.

Wood Sections by the Solandi Process.

Thin sections of wood make good subjects for sun-printing. This is illustrated by the accompanying engravings, which were made from prints of three kinds of sections of the American ash (*Fraxinus*

Americana). The sections were obtained of W. R. Hough, who is an expert in that line of work, and are about one two-hundredth of an inch in thickness. There is of course no enlargement or decrease in

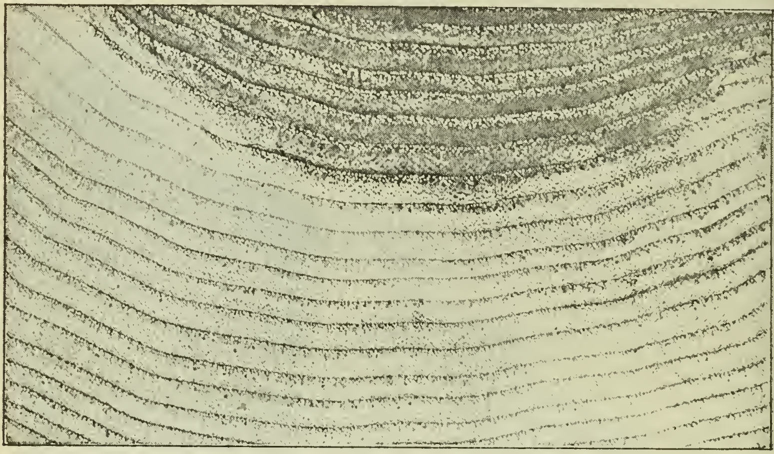


Fig. 7.

Section of ash wood—transverse.

the size, and each ring or pore is in its exact place. In making the engravings from the prints there is much loss of detail, but enough remains to aid those familiar with woods to distinguish the various tis-

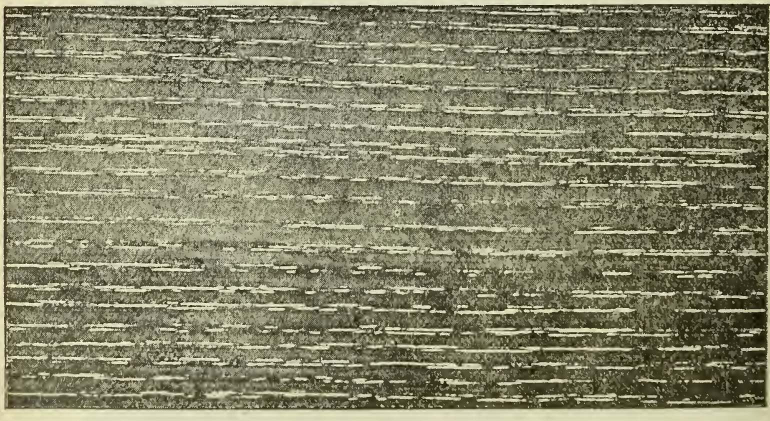


Fig. 8.

Section of ash wood—radical.

ies if not the particular sort of wood. There are many marked fferences between the transverse (Figure 7) and the radical section

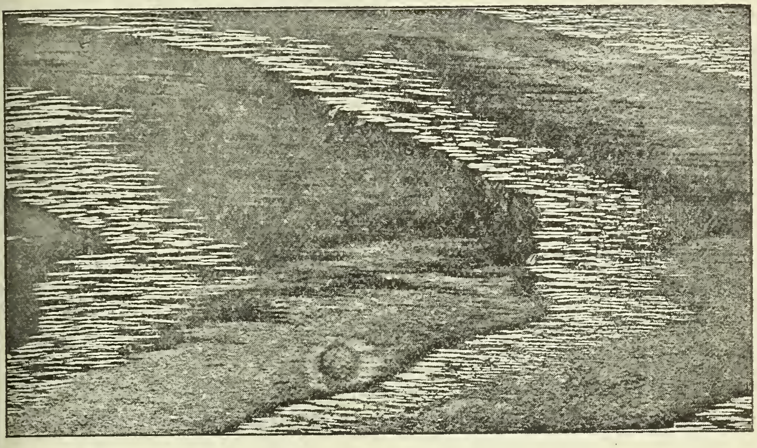


Fig 9.

Section of ash wood—tangential.

'igure 8), as also between those two and the tangential section 'igure 9), all three of which were or might have been taken from ie same log.

Shrinkage of Leaves in Drying.*

While it is well known that foliage undergoes a shrinkage in the 'dinary process of drying, the amount has not heretofore been condered great or perhaps worthy of mention. The Solandi process of in-printing, previously considered, permits of an accurate and rapid cording of the shrinkage of foliage, and by means of it accompanyg outlines are obtained and figures deduced below. Figure 10, iowing the shrinkage, is kindly loaned by the Torrey Club, in whose ulletin it first appeared.

Fresh leaves were measured by securing sun-prints as soon as conenient after being gathered. They were then put in press and dried the ordinary way for making herbarium specimens. After they ere fully dried a second print was taken or the leaf itself used, and

*Read before Section G. A. A. (?) A. S., Madison, Wis., August, 1893, and pubshed in the Torrey Bulletin.

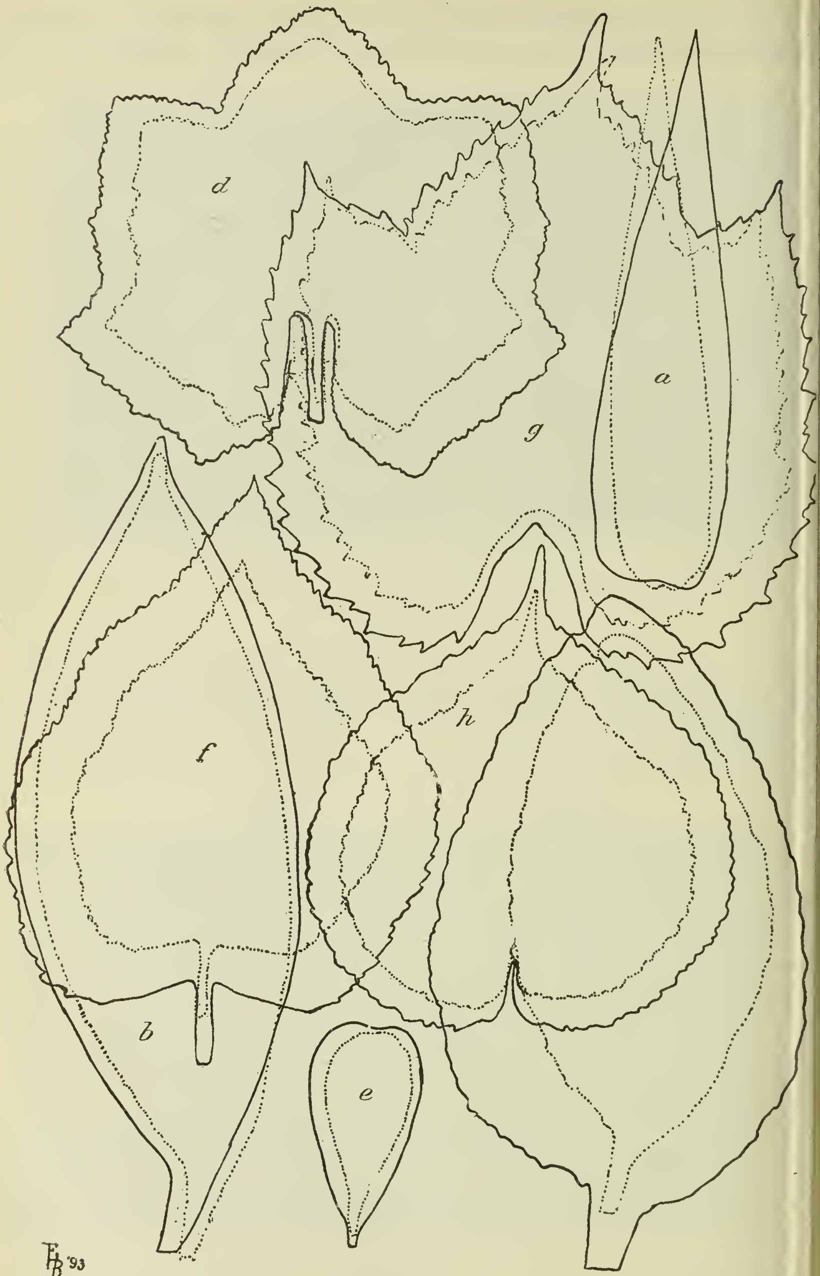


Fig. 10.

Outlines showing shrinkage in leaves in drying

rom these two measurements the comparisons are made. It is of ourse an easy matter to take a print each day up to the time the leaf s dry, and in that way determine when in the period of drying that he greater shrinkage takes place.

In order to determine what portion of the leaf surface underwent he more contraction many of the samples of leaves were first brought vith the surface upon a "card" used by hostlers in combing the manes of their animals. In this way small holes, practically equidistant, were made in the blade, and by means of these, the central ones being aken as fixed points, the shrinkage for all surrounding areas is letermined.

The leaves of endogenous plants shrink less than those of the exogens and very little in length. Thus, a leaf three inches long of a cultivated cypripedium, gathered in its full vigor, loses but a small fraction of an inch in its length, and the same is true of fresh green leaves of grass (Panicum), shown at *a*, while a five-inch-long leaf of lily-of-the-valley (*b*) shrunk largely in width, but almost none in length. But a somewhat similar leaf (Helianthus) as to shape and total area, shrunk greatly in all directions and lost 27 per cent. of its original surface. The common plantain (*Plantago major*) bears a large leaf which exhibited a striking amount of shrinkage, as shown by the outlines of the fresh and dried leaf at *c*. The amount of loss in this instance was 44 per cent. At *d* is shown in its two dimensions a hollyhock leaf, this being of the palmate type. This leaf, while fresh, was punctured, in a manner previously described, and the inner line shows how nearly equal the shrinkage was upon all sides. In the center of the lower portion of the plate is the outline of a fresh leaf of the purslane (*Portulacca oleracea*), and within it, the same whe dried. This is a leaf with very little framework.

A most striking example of shrinkage is seen in the outlines for a catalpa leaf, shown at *f;* however, this leaf was gathered before it had reached its full size, and its loss was 45 per cent. At *g* is shown a grape leaf and one of an abutilon at *h*.

The following table gives the per cent. of shrinkage of several kinds of leaves :

ENDOGEN.

Pontidera	11	per cent.
Lily-of-the-Valley	14	"
Orchid	19	"
Panic grass	27	"
Average	18	"

EXOGEN.

Hollyhock	21	per cent.
Maple	22	"
Smartweed	23	"
Helianthus	27	"
Purslane	35	"
Plantain	44	"
Catalpa	45	"
Average	31	"

The average for the two groups is almost exactly 25 per cent., or in other words, a loss by shrinkage in the drying of foliage of one-fourth the original size.

There are many reasons why types of plants should be seen by all monographers, but if types are so essential, the writer, in view of the above facts, would plead for a sight of the fresh plants whenever possible. It is fortunate that descriptions are made in large part from dried specimens or else the measurements for leaves, if at all precise (as usually they are not) would be uniformly too small for the green foliage.

A study of the outlines thus obtained leads to the conclusion that the greater shrinkage is in those localities containing the fewest veins and ribs. It is possible that there is a law of shrinkage to be expressed in the following terms: Leaves in drying under uniform lateral pressure shrink in all parts and around and toward the geographical center of the mass of tissue composing its framework. A mere general and condensed form of this law is: Leaves in drying under pressure shrink towards the mass-center of the framework.

Fungi Upon Weeds—The Thistle Rust.

There are many fungi that prey upon weeds, and in so far as this is the case, such fungi are the friends of the crop-growers, provided that the weeds do not thereby become the means of propagating species which are also parasitic upon economic plants. Thus, the common shepherd's purse is frequently attacked by a mould (*Cystopus candidus*, DBy.), which, distorting the stems and flowers, does much towards checking the advance of the weed. At the same time, this same mould will thrive upon several other members of the mustard

family cultivated for food. It follows, therefore, that a fungous parasite upon a weed is not necessarily an unmixed good. A similar mould (*Cystopus Portulacæ*, Pers.) upon the purslane confines itself to that miserable weed, so far as known in this country, and therefore in encouraging it upon the "pusley," there is no danger of causing its wide growth upon cultivated plants.

Within the last two or three years the Canada thistle has suffered greatly from the attacks of a rust (*Puccinia suaveolens* (Pers.), Rostr.). Whole plants become rusted throughout all their stems and leaves, fail to attain half their normal size and die down to the ground at least by midsummer. Other plants may escape for a season and appear in usual vigor while surrounded with those already destroyed with the rust. This fact would seem to indicate that the time of attack is early in the year. Attempts have been made to inoculate plants by carrying the leaves and stems of rusted specimens to localities where there was no rust and placing them upon, around and among healthy plants, but with no direct effect. As has been shown in many other cases, it is likely true here, that the time for inoculation may be while the plants are small. This matter of the attack of fungi being made while the plants are young was treated in the report for last year, under the title of "Fungi Injurious to Weed Seedlings."

The importance of the thistle rust cannot be overestimated, for when most active it proves the most effective means of eradicating a much-dreaded pest.

The following from a letter of a farmer is quite to the point in hand: "Two years ago about an acre of our farm was overrun with Canada thistle, but by the time they were in full bloom a rust struck them and hardly a seed of the plants matured. We plowed the land in the fall, and last year scarcely a thistle appeared. If this rust could be widely disseminated through the country the Canada thistle would receive a substantial check."

Diseases of the Strawberry.

The leading fungous diseases of the strawberry described in the books are, beginning with the worst, namely:

The ordinary leaf spot (*Sphærella Fragariæ* (Tul.), Sacc.); leaf

blight (*Phyllosticta fragaricola*, D. & R.); leaf spot (*Septoria aciculosa*, E. & E.); leaf spot (*Ascochyta Fragariæ*, Sacc.); strawberry anthracnose (*Gleosporium Fragariæ*, Lib. & Mt.); leaf blight (*Ramularia modesta*, Sacc.), and mildew (*Peronospora Fragariæ*, B. & C.)

The Strawberry Leaf Spot.

(*Sphærella Fragariæ* (Tul.), Sacc)

The most common fungous disease of the strawberry is the so-called "Leaf Spot," "Sun-scald" or "Strawberry Rust." It is, doubtless, true that it has been charged with more injury to the strawberry than is its due, but it is conspicuous and widespread and therefore has been the subject of considerable study in Europe and America. A full treatment of this fungus, giving the various forms in its life history, may be found in Professor Scribner's report of the Chief of Section of Vegetable Pathology for 1887. This is accompanied by a full-page colored plate, concluding with a bibliography up to date. Since then a bulletin (No. 14, December, 1889), by Professor Dudley, of the New York (Cornell) Experiment Station, devoted almost entirely to this fungus, has been issued. A large portion of Bulletin No. 31 (December, 1890) of the Kentucky Station, by Professor Garman, deals with this pest, and mention of it, long or short, may be found in many other places, chiefly concerning the amount of damage done or success with remedies applied. Professor Dudley concludes that the strawberry leaf spot fungus passes the winter in the foliage, and is amply provided with various kinds of spores for its rapid propagation. It therefore follows that the destruction of old foliage in autumn is a proper preventive. Professor Garman has attained satisfactory results in spraying the beds with Bordeaux mixture, the application to be made at intervals of two weeks. His observations upon a large number of varieties show that some sorts are rarely attacked, while others are generally injured. As varieties are often local, and soil, season and other circumstances differ, it is not safe to infer that a sort healthy in one place will always be so. The only method of determining the relative freedom from leaf spot is to make a study of the subject in the home grounds.

In addition to the above, Dr. Thaxter, in the annual report for the Connecticut Experiment Station, 1889, p. 174, states that "it causes

even greater injury on the fruit stems and hulls than the leaves, cutting off the supply of nourishment for the berries and disfiguring them by the withering of the calyx.

Another Leaf Spot.

(*Ascochyta Fragariæ*, Sacc.)

The Ascochyta disease, to the naked eye, might easily be mistaken for the Sphærella. Its microscopic structure and habits of growth, while differing from those of the latter, are of special interest only to the student of the subject, and until there is a special remedy or treatment for each, no further consideration need be given here.

The same is true of the other members in the list given near the heading of this article.

A New Strawberry Leaf Blight.

Mr. F. L. Stevens, in November, 1892, while a special student in my laboratory, and upon a visit to his home in Syracuse, N. Y., obtained specimens of a blight upon strawberry leaves, which has been under investigation since that date, and upon which the following report is made:

The blight affects the foliage, and principally the older leaves. Those lying upon the ground are usually the most diseased, this being due to the more favorable conditions there obtaining. Upon a second visit to Syracuse, Mr. Stevens went to a number of strawberry fields, and was able to confirm the opinions of strawberry-growers in that region that this trouble is quite serious. One large grower claims that more than a half of his crop has been destroyed by this disease, and from a study of the nature of the trouble, it is reasonable to conclude that this pest is sufficient to account for all the injury complained of. Since the discovery of the blight in Syracuse the fungus has been looked for in many parts of New Jersey, and it is safe to conclude that it is far from rare. There is reason to suppose that it may have been overlooked, because often accompanied by the other forms of strawberry leaf blight.

The fungus that causes the destruction is apparently a member of the genus Aposphæria. There is a near neighbor, *Phyllosticta fragaricola*, Desm. & Rob. This is a European species; has the margins

of the spots of a red color; the pycnidia few and scattered, and the spores without guttulæ. Our species has quite the opposite characteristics. It seems to have a preference for the upper portion of the leaf attacked, but develops its pycnidia equally over the somewhat V-shaped area and on both sides of the leaf.

The vegetative portion of the fungus consists of minute filaments, which extend in all directions through the substance of the leaf, causing at first a loss of the characteristic green color, followed soon by a discoloration that shortly becomes brown. At this time the spores-vessels (pycnidia) begin to appear as minute pimples scarcely differing in color from the other parts of the affected leaf. As the spores mature the pycnidia become of an amber color and rise promi-

Fig. 11.

Magnified view of pycnidia upon strawberry leaf.

nently above the surface of the leaf, as seen in the magnified view in Figure 11, each pycnidium having an opening bordered with brown, through which the spores escape as a gelatinous coil when water is applied to the dry affected part.

The appearance of a diseased leaf is shown in Figure 12, where the affected portion is seen to be near the middle of the leaflet. Sometimes only a single leaflet is diseased; in other cases all three leaflets are equally affected and destruction quickly follows.

Inoculations of healthy strawberry foliage with the spores of the fungus under a moist bell-jar in the laboratory gave brown spots with well-developed pycnidia in ten days, the spots afterwards spreading rapidly.

Treatment for this Blight.

A knowledge of the nature of the fungi should naturally lead to some rational employment of remedies. It has been shown that the foliage is the portion most affected, the fruit and other parts of the plant suffering only as the leaves are thwarted in their work of elaborating nourishment. Young leaves as a rule are not affected, and the older the foliage the greater is its danger of becoming the home of disease. Old leaves are therefore the portions which serve to harbor the enemies and keep them over the winter season. Such old foliage having done its best work for the plant can be disposed of with little loss to the plant in vital activity and at the same time be a means of depleting the ranks of the enemy. Therefore it can be

Fig. 12.

Strawberry leaf showing blight.

confidently recommended, both for the reasons above stated and from results obtained from actual experiments, that any badly-spotted foliage should be removed whenever it is found. This rule hold true even when the ravages are such as to blight the leaves generally. New leaves quickly form and therefore relief may be found in a mowing of the bed, raking the leaves off and burning them, the bed soon being dressed in a new garb of healthy foliage.

How best to remove the blighted foliage is somewhat a question. If all were equally effective in destroying the enemy, and equally inexpensive and harmless to the plants, the only question to be considered

would be the taste of the owner. The scythe is effective, harmless, inexpensive and swift. Some * use chemicals, as sulphuric acid sprayed on the plants, which burns the foliage, kills the germs and a new growth replaces the old. There is danger of using the acid so strong as to affect the crown, and there is also a chance of injuring one's clothing in the operation. Other things being equal there is always an objection to the use of heroic remedies that may do more destructive work than is desired.

It is possible that spraying with Bordeaux may prove as effective with this blight as with the common leaf spot; in fact the good results already obtained are very likely in part a checking of this blight, not before distinguished from the leaf spot.

Club-Root of Cabbage and its Allies.

The Club-root of the cabbage and turnip is an old enemy, having been known in Europe for more than a hundred years, and, being a fatal malady, with peculiar and prominent characteristics, it has received one or more names, often quite descriptive, in several of our leading modern languages. Thus, in Germany it is called "Kohlhernie;" in France, "Maladie digitoire;" in Belgium, "Vingerziekt," and Russia, "Kapoustnaja kila;" in Great Britain it bears the names of "anbury," "hanbury," "finger-and-toes" and other equally expressive terms, while with us, "club-root," "club-foot" and "clumpfoot" are the leading names for this trouble, the process being spoken of as "clubbing."

The injury to the crops attacked may be considerable, sometimes incurring almost a total loss, and in the aggregate the destruction for the whole country is doubtless represented by millions of dollars. It is particularly severe in the eastern portion of the United States, but is not unknown in the West and South, and during the past season (1893) has prevailed extensively in the truck regions around the large cities of New York and Philadelphia. New Jersey cabbage and turnip growers have suffered so heavily of late years as to suggest the subject as suitable for special consideration by the Experiment Station. Some facts with a practical bearing upon the question

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*Col. A. W. Pearson, in Bulletin No. 11, Dept. of Agr., Sec. of Veg. Path., p. 49.

of how the club-root lives over from one year to another, have been literally unearthed, which alone might warrant this publication. The weed plants that harbor this enemy, with engravings showing the pest, will be considered in their proper places later in this paper.

The Nature of Club-root.

In order that the reader may derive the most practical good from any suggestions as to use of preventives and other treatment of the disease, it is best to place before him the facts thus far obtained concerning club-root. The name of the malady is quite descriptive, for it is an affection of the roots, which become much distorted. The roots may begin to show enlargements while they are quite small and before the plants are more than seedlings. Thus, cabbages while growing in the hot-bed may show unmistakable signs of "clubbing," followed by a loss of vitality throughout the whole plant. The affected parts soon begin to decay, becoming very offensive, and, from places near by, other roots are developed, which, in turn, become swollen and distorted into various shapes.

Figure 13 shows three young cabbage plants taken from a field that was nearly ruined by the club-root. Instead of the numerous long fibrous roots, by means of which the plants are able to obtain the required nourishment from the soil, there is in each an extravagant malformation consisting of a much-knotted and enlarged root system. The engraving of the three samples is from a photograph, and shows the general appearance so well that further description is unnecessary.

That which is of the most interest in this connection is the cause of the peculiar development and consequent destruction of the infested plants. As in nearly all instances of similar abnormal structures, these root-galls were long ago assigned to insects. A careful study of their development failed, however, to convict any species or group of insects of these depredations, and after much speculation, and no end of articles in the agricutural journals and elsewhere, it was reserved for M. Woronin, a European botanist, after three years (1873–76) of painstaking and exhaustive study, to explain the nature of the subject before us. From his published results * in particular and a recent

* Plasmodiophora Brassicæ. Urheber der Kohlphlanzen Hernie. Prmgs. Jahr. F. Wiss. Bot., Bol. XI., 1878, Plates 6.

paper* by Mr. A. C. Eycleshymer, the information as to the microscopic structure is largely obtained.

Instead of any insects being the cause, although such decaying masses usually become the breeding-places for them, Woronin found that a low form of fungus was constantly present in the affected parts.

Fig. 13.

Three small cabbage plants badly "clubbed."

This parasitic organism is only seen with the higher powers of the compound microscope. The family of fungi to which it belongs, namely, the slime moulds, is widely distinct from the mildews, rusts and smuts, and some of Woronin's and Eycleshymer's illustrations, as given in two plates which accompanied the latter author's paper

*Club-root in the United States; Journal of Mycology, Vol. VII., p. 79, Plates 2.

and kindly loaned by Professor Galloway, are here reproduced, to make the nature of the club-root fungus clear. Ordinary fungi, like the grape mildew, corn smut, wheat rust and celery leaf-spot, have long, slender feeding threads which work their way through the tissues of the affected plant. There are no such threads with the cabbage slime fungus.

In Plate I., the first figure shows a specimen of diseased cabbage, natural size, and Figure 2 a "clubbed" turnip. Figure 3 is a portion of a section of a turnip root, and Figure 4 is a rootlet of diseased cabbage, seven weeks after infection. At Figure 5 is shown a much-magnified view of a section of root (Figure 4) along the line *a*, *b*. A portion of a turnip root, seven weeks after infection, is shown at Figure 6, natural size, and at 6, *a*, are shown cells from the section along the line *a*, *b*, of Figure 6, and two hundred times magnified.

In Figure 5, scattered irregularly midway of the center and circumference, are large cells filled with a slimy substance and differing from the other and smaller cells. These are infested with the slime mould, and, on account of the presence of this parasite, the cells undergo remarkable enlargement, and an influence is communicated to the other neighboring cells so that the root becomes much swollen and even distorted. In its early stages of development the fungus is simply a semi-liquid substance within the cells of the root tissue; but as it reaches maturity the contents of the infested cells become granular and finally they contain a multitude of minute spherical bodies, which are the spores of the mould. In short, this fungus, in the form of a slime or plasma, obtains entrance to the cells of the growing root and there robs the infested tissue of its vital fluids, and, gathering new forces to itself, fills the cells with its own substance. This semi-fluid material then begins the process of spore formation, which results in the production of millions of minute bodies, each of which is capable of a new growth when conditions are favorable.

The three cells, *a*, *b* and *c*, in Figure 6, *a*, help to show these peculiarities, but the second plate is devoted in particular to the points of development of the fungus. Thus, Figure 9 is a portion of a section of Figure 10 at the line *a*, *b*, and magnified six hundred times. The two cells shown shaded were completely filled with the plasma or slime of the mould. The spores which form from this semi-fluid substance are spherical, as shown at Figure 12, and in germination their contents come out as seen at *a*, becoming naked bodies capable

Plate I.

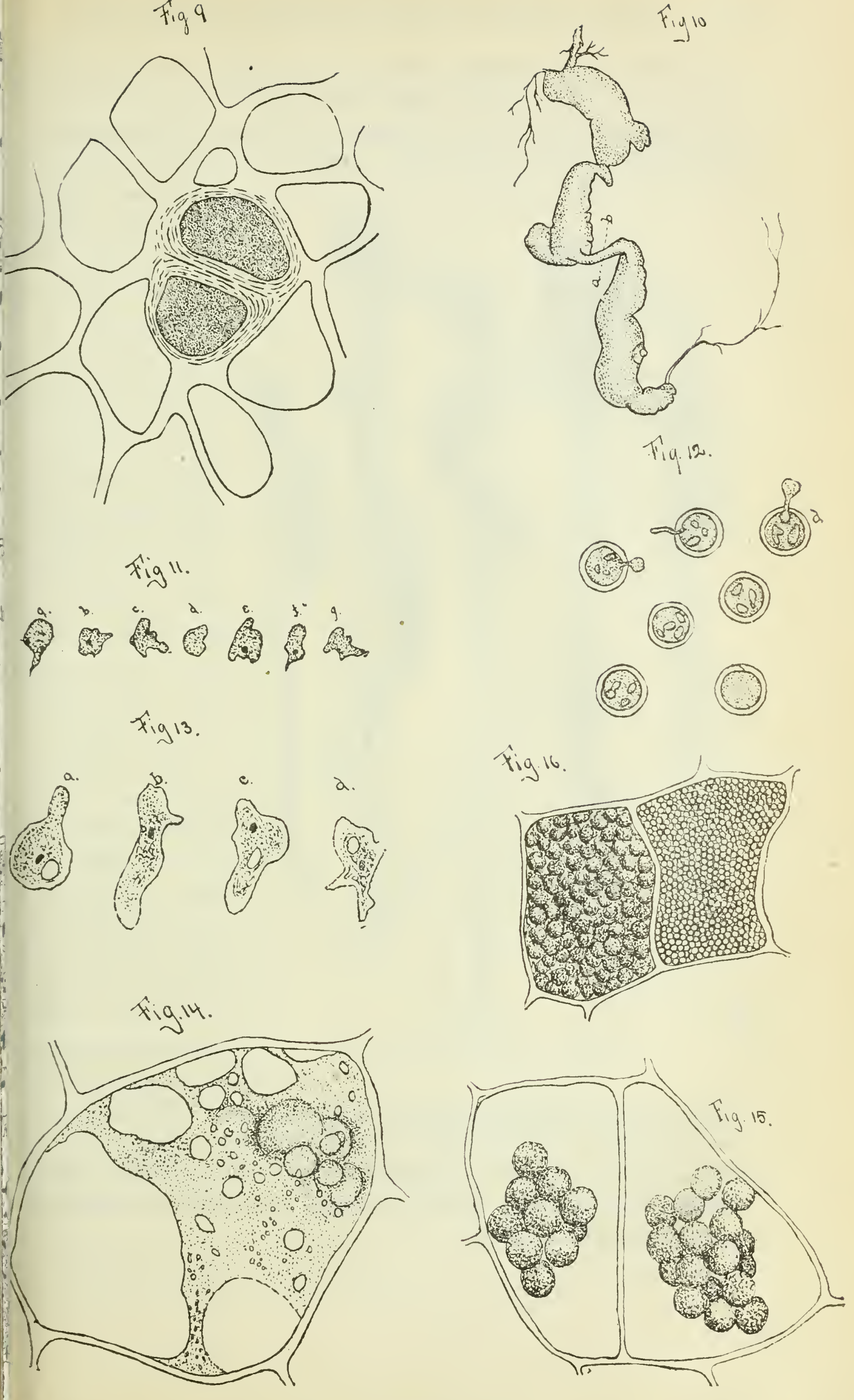

Plate II.

of movement and change in outline, the latter fact being illustrated a Figure 11. These motile bodies may unite with their fellows and form masses of semi-liquid substance, as shown in different forms a Figure 13. A single cell of the cabbage root is shown at Figure 14 in the early stage o the disease, magnified six hundred times while at Figure 15 ar two cells later in th development and showing the formation of the plasma int spheres. Figure 1 shows the appearanc of the fungus two hun dred times enlarged.

Fig. 16.

Club-root in roots of shepherd's purse.

We have trace above the life of th obscure club-root para site, from its appear ance in the root as slime in certain cell to the formation o multitudes of spore in these same cell By the decay of th roots, which take place rapidly, and wit much offensive odo the spores are set fre in the soil. Thes spores there germinat by producing movin bodies capable of penetrating or being absorbed by the thin walls o the hairs and other superficial cells of the roots. The soil become diseased in the sense that the germs, formed in the swellings and othe distortions of the roots, are set free and the earth holds them for a indefinite length of time.

The Club-root in Weeds.

It is generally known to the students of the club-root fungus that it is not confined to the cabbage and turnip, and this leads to the statement of the botanical name of the parasite we have been considering. Woronin found it so different from all the other slime moulds as to warrant its being put in a separate genus, which he named *Plasmodiophora* — that is, the plasma or "slime bearer;" and, as it infested the cabbage and turnip, both members of the genus Brassica, he made the species *Plasmodiophora Brassicæ*, Wor. Since then two other species of the same genus have been discovered, namely, *Plasmodiophora Alni*, Wor., upon alder roots and *Plasmodiophora Elæagni*, Schroet., on the roots of Elæagnus. Various works make mention of the club-root being found upon many species of the mustard family, but it is unfortunate that the particular species are not given. Saccardo * states that it is found in several cruciferæ (Brassica, rarely *Iberis umbellata*). Dr. Zopf † adds to these, "Levkoje"—that is, the Stock (*Mathiola incana*), also mentioned

Fig. 17.
Roots of hedge mustard with club-root.

* Sylloge Fungorum, Vol. VII., p. 464.
† Die Pilzthiere oder Schleimpilze, p. 129.

by Woronin. Sorauer* and Frank† simply confirm the above state-ments. Eycleshymer‡ says: "The plants affected are for the greate part confined to the genus Brassica, including the cabbage, cauli-flower, turnip, ruta-baga Halsted has recently de-scribed it as occurring i the radish. In Russia i affects the genus Mathiol and Iberis."

Fig. 18.

Cauliflower with club-root.

So far as the actua species of the host of th club-root fungus can b determined from th books at the writer's dis-posal, the list is *Brassic oleracea* (varieties), *B rapa*, *Raphanus sativus Iberis umbellata* and *Mathiola incana*. This i only five species, the las three of which are know to be but rarely affected.

In view of these facts it is interesting to add t the list two other genera each with a single species but both are among ou most common weeds namely, the shepherd's purse (*Bursa pastoris*, L. and the hedge mustard (*Sisymbrium vulgare*, L.

Figure 16 shows a group of the infested roots of the shepherd's purse. It must be borne in mind that the roots of this prevalent weed are not succulent and the galls are correspondingly small However, there is no difficulty in distinguishing a diseased from a healthy plant, even from the appearance of the plant above ground

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* Pflanzen Krankheiten, Part II., p. 69

† Die Krankheiten der Pflanzen, p. 238.

‡ Club-root in the United States; Journal of Mycology, Vol. VII., p. 49.

when thoroughly infested, it having a dwarfed and sickly-yellow appearance.

In Figure 17 is seen a similar group of the clubbed roots of the hedge mustard. The general appearance of these galls is quite differ-

Fig. 19.
Turnips with club-root.

ent from those of the shepherd's purse, being more regular in form, standing out like dark warts from the otherwise well-shaped roots.

In this connection, to add to the information concerning the club-root upon our crop plants, an engraving each of the cauliflower (Fig. 18), turnip (Fig. 19), Brussels sprout (Fig. 20) and kale (Fig. 21)

are added. They were all made from photographs by Prof. Smith, of fresh specimens collected by Mr. J. A. Kelsey. The cauliflower and cabbage resemble each other in the general form of the "club" that is produced, and in like manner the kale and turnip galls are somewhat alike. But there is no uniformity in the matter, and the size and shape of the malformations are largely determined by circumstances.

Precautions and Treatment.

From a consideration of the nature of the club-root fungus and a knowledge of the different kinds of plants infested by it, there may be some suggestions gathered as to preventive measures. When it is understood that the club-root and all the injury to the crop accompanying it is due to an internal subterranean parasite, it becomes evident that no treatment to which the infested plant may be subjected can give promise of a cure. Preventive measures must be relied upon, and, in the first place, all the refuse of a cabbage, turnip or other infested crop should be removed from the soil and burned. To leave cabbage stumps in the field, feed them

Fig. 20.
Brussels sprout with club-root.

to live stock or throw them in the compost heaps, are three of the best methods of propagating and spreading the malady on the farm. It is not enough to destroy the roots, for the Plasmodiophora is found also in the leaves, as Woronin took particular pains to show by means of an engraving in his paper.

Fig. 21.

Kale with club-root.

Seedlings grown in the hot-bed should be examined carefully, and if they show signs of the club-root, consigned to the fire. If only a portion of the plants are clubbed, it may be wise to discard the whole lot rather than lose the crop in the field. Start with healthy plants.

In view of the fact that the soil may become more or less impregnated with the germs during the growth of a crop susceptible to the Plasmodiophora, it is evident that a wise precaution consists in a judicious rotation of crops. Just what that rotation should be is a question for each grower to decide for himself; but, for the best results, cabbages or any allied crop should not be upon the soil oftener than once in three years. Cabbage, kale, Brussels sprouts, kohlrabi, turnips or radishes should not follow each other if club-root is prevalent.

It is possible to get relief by the use of some of the commercial fertilizers; but this needs confirmation through trial. It is a fact that is being acted upon in some of the large truck regions near New York, that lime is an effective preventive of the club-root, and, by its constant use, at the rate of seventy-five bushels or so per acre each year, cabbages have been grown at frequent intervals—almost yearly, upon the same soil. It is likely that a soil naturally abounding in lime may be the best suited for cruciferous crops, so far as club-root is concerned.

Lastly, it has been shown that common weeds harbor this fungous enemy, and, while the farmer may be thankful for the loss of his hedge mustard and shepherd's purse, through "clubbing," this is a case where weeds can be more cheaply destroyed in some other way.

Conclusions.

Club-root, an old enemy to cabbage and turnip in Europe, has been quite destructive to these crops in New Jersey during the past few years.

The malady is due to a microscopic parasite which infests the cells of the roots, causing them to become swollen and distorted.

The spores of the fungus, upon the decay of the part affected, become scattered through the soil, and from thence the enemy enters the host plant.

Plasmodiophora Brassicæ, Wor., infests several plants of the cabbage family, including turnip, kale, radish. stock and candytuft.

Two common weeds, namely, shepherd's purse and hedge mustard, are now to be added to the list of plants infested with club-root.

Preventive measures must be relied upon, for the affected parts of a plant are below ground and not readily reached by any fungicide.

If the crop is diseased, all refuse at harvest-time of roots, stems and leaves should be burned.

All seedlings from hot-beds with signs of club-root should be destroyed, and, if possible, use only plants from beds in which there is no disease.

Cabbage, kale, Brussels sprouts, kohlrabi, turnip or radishes should not follow each other on the same land if club-root is prevalent.

Lime added to the land, seventy-five bushels per acre, has proved effective. It is possible that some commercial fertilizers may be found to check the trouble.

Keep the land free from shepherd's purse and hedge mustard, and other weeds of the same family, as their roots become "clubbed," and thereby propagate the enemy.

Field Experiments with Sweet Potatoes.

Mr. George W. Jessup, of Cinnaminson, N. J., desiring to experiment in the field with the view of obtaining some check or remedy for the soil rot of the sweet potato, with which he was troubled, carried out, during the past season, the following series of field trials on infested land:

(1) On May 13th, two rows, while still open and before manuring, were sprayed thoroughly with the Bordeaux mixture.

(2) On May 13th, two rows sprayed as in (1) after the manure had been placed.

(3) Two rows left untreated.

(4) On May 13th, two rows sprayed after they were made up and before setting the plants.

(5) On May 20th, two rows with the plants sprayed directly after setting.

(6) On August 10th, two rows sprayed after the plants had run vines eighteen to twenty inches long.

The above series was repeated on the adjoining rows with the exception that there was some difference in the quality of the manure and fertilizers employed.

On account of a cool spell setting in soon after the plants were put in the field many of them perished and replanting was resorted to, and later still, other plants failing, some sugar corn was planted in the same rows to fill out vacancies. On this account, therefore, the conclusions may not be as valuable as they might have been had the entire ground been occupied by sweet potato plants and they all of the first planting.

The following gives the results so far as the soil rot is concerned :

						Total.	
Row.	Lbs.	Oz.	Row.	Lbs.	Oz.	Lbs.	Oz.
(1)	6	2	(7)	7	6	13	8
(2)	10	6	(8)	14	...	24	6
(3)	11	6	(9)	15	8	26	14
(4)	12	...	(10)	24	...	36	
(5)	11	8	(11)	24	...	35	8
(6)	16	2	(12)	16	10	32	12

In the above table the rows are given from 1 to 6, then repeated from 7 to 12. Rows 1 and 7 received the same treatment; 2 and 8, etc., so that the totals for the two sets are given in the last column. It will be seen that there is an agreement between rows 1 and 7, and the total of potatoes affected with the soil rot is lower than for any of the other rows. In fact, there is an increase from first to last—that is, from 1 to 6—of the amount of soil rot. In short, the difference in amount of "marked" potatoes was nearly as 1 to 2 in favor of the rows which were sprayed while open and before the plants were set. This would indicate that spraying upon rows before the addition of manure is the better way of treating the ground for the prevention of the soil rot of the sweet potato.

Identity of Anthracnose of the Bean and Watermelon.

The fungus causing the spotting of bean-pods, shown in Figure 22, was first observed by Lindemuth, at Popplesdorf, in 1875. It was named *Glœosporium Lindemuthianum* in his honor by Saccardo and Magnus and described in Michelia, I., 129. In 1878, in his Report of the Section of Vegetable Pathology for 1887, Professor Scribner records the presence of setæ in the acervuli and suggests that the species might be placed in the genus Colletotrichum. Briosi and Cavara, in 1889, made the transfer of the species to that genus and the name became *Colletotrichum Lindemuthianum* (S. & M.), Bri. & Cav., and as such is published as No. 50, in "Briosi and Cavara, Funghi Parassiti Della Plante Cultivati." Of special interest in this connection is the statement made by Professor Scribner, in the report previously cited, that "In this country the disease attacks watermelon rinds as well as beans."

Fig. 22.
Anthracnose of bean.

Turning now to the anthracnose of the watermelon shown in Figure 23, it is found that three species of Glœosporium are recorded for cucurbitaceous fruits, the *G. Lagenarium* (Pass.), Sacc. & Roum., only requiring attention.

In Farlow's Host Index this species is recorded for the following cucurbits: Watermelon (*Citrellus vulgaris*), muskmelon (*Cucumis Melo*), cucumber (*Cucumis sativus*), pumpkin (*Cucurbita Pepo*) and squash (*Cucurbita* sp.)

Early last summer a serious blight of the muskmelon, found at

Port Monmouth, N. J., by the writer, was traced to a Colletotrichum which agreed in all particulars with the one upon the bean. Blighted foliage of the watermelon, gathered the season before, upon examination showed the same characteristics of acervuli, spores and setæ. A blight of cucumbers, bitterly complained of in 1890 through the central portion of the State, was due to the same anthracnose.

The seemingly perfect agreement of the fungus of these three cucurbit hosts with the Colletotrichum of the bean suggested that the

Fig. 23.

Anthracnose of watermelon.

setæ of the so-called *Glœosporium Lagenarium*, Pass., had been overlooked and inoculations were made for further evidence in the matter. It was not difficult to transfer the watermelon anthracnose to the bean. But the points that may be of interest were the results with a third fruit, because admitting of parallel inoculations for both the bean and the watermelon.

Citrons small enough to go under a medium-sized tall bell-jar were selected, and at first inoculations were made from the watermelon,

here and there, under the skin of the citron, the virus taking quite uniformly and growing luxuriantly.

The Colletotrichum virus was taken from the bean and applied to the citron at a few points upon the side of an ink line drawn lengthwise of the fruit, while similar inoculations were made from the watermelon on the other side. Both grew with about equal rapidity, and when prolonged, the result blended, showing indentical results as seen in Figure 24. In short, the appearance to the naked eye was the same, and the microscope showed no differences. The work was repeated with uniform results.

Fig. 24.

Citron culture of anthracnose.

Specimens No. 1,173, b. Ellis, N. A. F., were distributed as "*Glœosporium Lindemuthianum*, S. & M., on watermelon rinds, Wisconsin, September, 1885, Prof. A. B. Seymour." At a later date, a new label was issued changing the species *Glœosporium Lagenarium*, Pass. These specimens show an abundance of setæ in the acervuli and in all points agree with the virus as above, used for inoculation.

Years later, specimens No. 2,448, Ellis, N. A. F., were distributed

as *Glœosporium Lagenarium*, Pass., var. *foliicolum*, E. & E., *a* being upon *Cucumis sativus* leaves and *b* upon *Citrellus vulgaris* foliage There are also added leaves of muskmelon with the same fungus.

These are all first-class samples of apparently one and the same Colletotrichum, with a Phyllosticta associated with it upon the musk-melon. A note accompanies the specimens as follows: "Briosi and Cavara in their Funghi Parassiti No. 100, place this in Colletotrichum (*C. oligochœtum*, Cav.), but if, as we think, this is only a foliicolous form of *G. Lagenarium*, it should be *C. Lagenarium* Pass."

An examination of Cavara's species does not show marked points of difference from the Colletotrichum treated above under *Glœosporium Lagenarium.* According to the author, the smaller spores and basidia, but chiefly the presence of setæ, serve to separate this from *Glœosporium Lagenarium.* In other words, he fails to realize that under further study the setæ have been found in the so-called *Glœosporium Lagenarium* as they were in *Glœosporium Lindemuthianum*

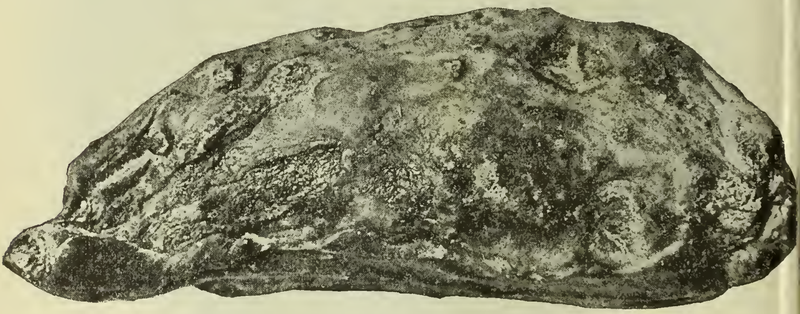

Fig. 25.

Cucumber fruit badly anthracnosed.

and both become Colletotrichums and, what is more, they are probably the same species.

It then remains to see what the name of the combined species shall be. The species under consideration was first published in 1868 by G. Passerini, in "Erbario Crittigamico Italiano," as follows: "*Fusarium Lagenarium*, Pass. Minutum plerumque orbiculare subepidermis nascens; sporæ, tereto-oblongatæ, rectævel curvulæ interdum oblongo-subclavatæ, nucleo grumoso fœtæ pallescentes e basidiis brevissimis densissimeque nascentes epiderme rupta cirrhose diffuentis

demum in acervos irregulares aurantiacos effusæ. Auf Fruchten einer Lagenaria."

This is prior to the *Glœosporium Lindemuthianum* of Saccardo and Magnus, and therefore the species for the anthracnose of the melon and the bean becomes *Colletotrichum Lagenarium* (Pass.), as suggested by Ellis, in 1890, in his XXV. Century of N. A. F., No. 2,448.

The following is the synonomy:

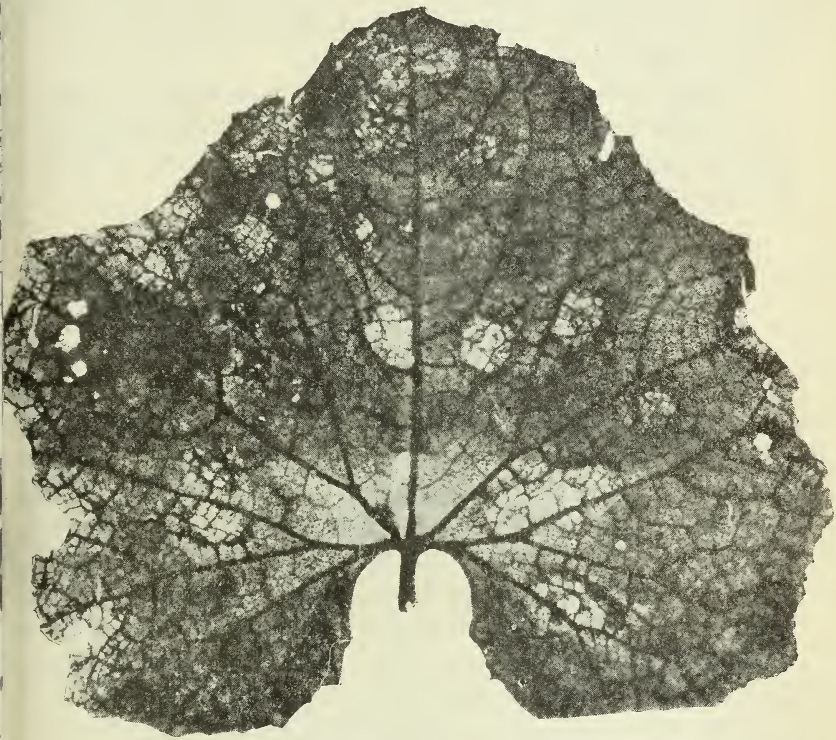

Fig. 26.

Cucumber leaf badly anthracnosed.

Fusarium Lagenarium, Passerini (1868).
Glœosporium Lagenarium (Pass.), Sacc. & Roum. (1880).
Colletotrichum Lindemuthianum (S. & M.), Briosi & Cavara (1889).
Colletotrichum Lagenarium (Pass.), E. & Hals., 1893.

In this connection it is interesting to state that early last spring the cucumbers brought from the South were badly attacked by the spot

decay, and some dealers in this vegetable-fruit lost heavily thereby Figure 25 was made from a photograph of one of a peck or more o specimens that were brought to the Station. The general appearanc is quite similar to the decay of the watermelon, the difference bein due to the thinner rind and more watery contents of the cucumbe Microscopically, the fungus is apparently the same.

The thought at once came to mind that in the distant transporta tion of this diseased fruit, at a time of year when Northern plant were small and most susceptible, there was an opportunity for th wide spreading of the anthracnose.

In Figure 26 is shown the appearance of a cucumber leaf that ha been blighted by the Colletotrichum; the field from which the leaf wa gathered, along with hundreds of others, was seriously affected an the crop almost ruined.

Fungous Diseases of the Muskmelon.

There have been three prominent fungous troubles of the musk melon (*Cucumis melo*) in the country during the past few years, an all of them are comparatively new. This may be due to the fact th investigations of such subjects have been more active of late than eve before, and old troubles seem new because their nature was unt recently entirely unknown. The first one to be mentioned is genuine downy mildew (*Plasmopara cubensis* (B. & C.), Humpl This is a fungus closely allied to the American mildew of the grap and is first cousin to mildews of lettuce, spinach, onion and the sti more dreaded rot of the Irish potato. It is in the midst of a destru tive group, and much damage may be expected from it. Until fou years ago this species was scarcely known in the United States. A that time it was observed upon cucumber vines growing in gree houses, but since then it has been found doing injury to the squas pumpkin, watermelon and muskmelon. The cut (Figure 27) is a engraving from a photograph of a cucumber leaf, which was select instead of a muskmelon leaf because it, from the nature of the smoot surface, showed the attacked areas far better than the foliage of th muskmelon. The fungus is the same, but upon the rank-growing an comparatively-smooth, thin foliage of the cucumber the trouble ca be recognized at a long distance. The mildew has the peculiarity

growing in angular patches, which sometimes occupy half of the area. The spore-bearing tufts of threads pass out the stomata upon the under side of the leaf and form a frosty covering, which later turns to an almost violet tint, due to the multitudes of spores, which are strongly colored. This violet color of the spores seems to be more strongly developed in the mildew that is upon the squash than upon any other of the cucurbitaceous hosts. It would need several engravings showing the anatomy of the parasite to fairly present the manner in which the threads of this fungus penetrate the tissue of the leaf and rob it

Fig. 27.

Cucumber leaf with downy mildew.

of the desired nourishment, but it must suffice here to say that, judging from what success has attended the use of fungicides upon the grape for the mildew, this trouble of the muskmelon is amenable to similar treatment.

The second muskmelon trouble is not disposed of so easily. It is one that has been complained of from all parts of the country, and especially in the South. Hundreds of sick plants were sent me last summer from various parts of New Jersey and New York, and a

large percentage were of this sort. It is not easy to describe the appearance, for no two plants were alike. Soon after the plants are up, and usually by the time they have reached out a foot or so upon the ground, the trouble begins. The stem may become moist in a manner to suggest what is termed "water core" in apples. This may be close to the base of the plant or midway between that point and the tip of the vine. Sometimes one leaf-stalk decays first, and the disease spreads from it to other parts. Occasionally the free young

Fig. 28.

Muskmelon leaf showing bacterial decay.

end melts away with the trouble. When tissue that is freshly diseased is examined it is found swarming with bacteria, and no other cause for the disorganization is to be seen. Not infrequently the leaves become spotted—that is, certain areas decay and fall away. If a leaf freshly affected is held towards the light the diseased places may be easily detected by the peculiar discoloration, being due to the excess of moisture—a sogginess, so to speak. A leaf that has been thus affected is here shown (Figure 28), but the diseased spots are not plainly

seen. It must be remembered that much of detail is necessarily lost in photo-engravings of all such subjects as these here displayed.

While in Mississippi two years ago, this disease of the melon was bitterly complained of, and from experiments made there it seemed likely that the bacterial trouble was associated with one of those of the Irish potato and the tomato. It is not unlikely that these diseases, which we are pleased to call bacterial troubles, are more general and widespread than many at first are willing to admit. In the North, for example, during the past season, there has been a great deal of bacterial decay of beans, both foliage and pods perishing from the attacks of these germs. From some carefully-recorded field notes it would seem very probable that these germs may live in the soil for a long time, and it remains to be shown that the bacterial disease of the potato of one year may not develop in the carrot, turnip or beet crop the next, and from that to the bean or the melon or some other crop the succeeding summer. Therefore, in connection with the bacterial melon disease, it is probable that the trouble may be carried over from year to year in the soil, and it is possible that it can be in the seed also, as has been demonstrated in the case of the bacterial disease of the bean. While this does not preclude effective treatment with fungicides, it only emphasizes the fact that one crop may not decay to its own kind alone, but entail the affection, through the soil or otherwise, upon a following crop. Spraying may check the ravages of germ diseases.

A third muskmelon trouble that came to the front last season was a leaf spot, reported as destructive in various melon-fields in New Jersey, by Professor Beach, of the Geneva Experiment Station, and by Professor Selby, of Ohio. A melon leaf that was badly affected with the leaf spot is shown in Figure 29. An examination of the light-colored spots under the microscope will show that a deeply-seated fungus is present. It is very different in structure as well as in general appearance from the mildews first mentioned and the bacterial trouble above spoken of. The Phyllosticta confines itself usually to the foliage, but in the younger parts it may be found upon the vine. The spores, instead of being borne upon long stalks, as in the mildew, are produced in small spheres, and when mature are exuded through a small opening upon its upper side. These spores germinate quickly, and thus tend to spread the blight. From the

nature of this fungus it seems quite certain that control might b obtained by spraying.

The whole subject of fungicides has been before the readers so fre- quently that it is unnecessary to more than say that either the Bor- deaux mixture or the ammoniacal solution of the carbonate of coppe

Fig. 29.

Muskmelon leaf spot.

will prove effective when sprayed upon the vines about once a week There are other fungi of the melon. Thus an anthracnose was occa- sionally met with last season, but as said at the outset, the thre above treated have been the leading fungous enemies, and probabl all can be subdued wholly or in great measure by judicious spraying and a careful consideration of soil sanitation and rotation of crops.

Some Fungous Diseases of the Pea.

There are several enemies of the pea, and not the least are those of fungous origin. Late-grown peas are quite sure to suffer, while those sown early in the spring are not at all certain to escape. The most conspicuous trouble coming under the present subject is given first upon the list.

The Pea Mildew.

(*Erysiphe Martii*, Lev.)

The mildew of the pea is a member of a large group of fungi infesting plants quite generally and causing damage to various crops, as, for example, the grape, cherry, and particularly the gooseberry. The mildew of the last plant is so destructive that gooseberries are grown with great difficulty and uncertainty in many parts of the country, and particularly the European sorts.

The mildew of the pea quite resembles that of the gooseberry, consisting first of a fine growth of microscopic threads over the leaves and vines, followed later by a multitude of minute dark bodies, which bear the spores. Leaves attacked by this mildew fail to attain their normal size and lose their full power for work, while the vines become weakened and the fruit shrivels and fails to develop plump seed.

It is doubtless true that the same treatment with fungicides recommended in Bulletin No. 86 would help to ward off this mildew. It has not been attempted largely, and it may be that the crop is so bulky and comparatively low-valued that for the mildew alone it might not pay to spray. However, as there are other fungous enemies to the pea it may prove profitable to treat them all with the Bordeaux or other mixture of equal value.

The Pea Rust.

(*Uromyces appendiculatus*, Lev.)

A genuine rust is occasionally met with upon the pea, but at rare intervals, and needs no further attention here save to state that it is the same as the rust of the bean, which does much damage.

The Pea Blight.

(*Ascochyta Pisi*, Lev.)

When the pea plants are nearly full grown and blossoms begin to appear the lower leaves frequently become blotched with yellow and brown and fall away, leaving only the upper portion of the plant with foliage. This is the work of a blight not easily shown except by engravings giving enlarged views of portions of the fungous enemy. The brown parts of the leaf when looked at closely are seen to bear many minute, dark bodies imbedded in the skin of the leaf. These flask-shaped sacs are the spore-bearing organs, by means of which the fungus is able to mature its multitudes of offspring and perpetuate its kind. In severe cases the stems, tendrils and even fruit become blotched with the Ascochyta.

A Second Pea Blight.

(*Septoria Pisi*, West.)

There is a member of the genus Septoria which produces results similar to those of the Ascochyta, the chief difference residing in the size and shape of spores. In this the spore cavities contain long, somewhat curved bodies, marked with cross-partitions. These spores flow out through the free opening when mature, and become widely disseminated.

Black Mould of Pea.

(*Pleospora Pisi*, Fl.)

The black moulds are gaining ground as enemies to field and garden crops, and the pea is no exception to the rule. This is one of those fungi that assumes at least two well-recognized forms in its development. For a time it may consist of a vast number of irregular, brown threads from the tips of some perpendicular branches. These spores are so numerous that with the network of threads bearing them the leaf or stem may be almost black. Along with these bodies there form, after a time, spherical structures of dark color, within which the spores are produced, but in a much more complicated manner than those of the Ascochyta or Septoria. Within the sphere there first develops a considerable number of oval bodies and afterward within these the spores are produced.

Failure of Pea Seeds to Grow.

During the past year several complaints have come to hand of seed peas failing to produce a crop. The peas, as they came from the store, looked comparatively healthy, but were found to contain, upon inspection, about 18 per cent. of seeds more or less injured by insects —probably the pea-weevil. These peas, when planted, failed, in a large part, to grow, and those that came above ground quickly showed signs of disease, and finally, after a few blossoms, imperfect pods were produced, but no crop was realized.

There are a number of reasons for this failure. In the first place, as before mentioned, a large per cent. of the peas are attacked by the weevil. These weevilled seeds, usually, do not grow. A thorough test of this matter has been made; the weevilled peas, those that were not at all broken or showed special signs of the work of the insect, have been planted and watched, and, as a rule, they failed even to show the first stages of germination. On the other hand, these weevilled peas quickly become the center of bacterial development, and shortly were exceedingly offensive. The sand employed was first burned to remove all organic matter, and afterwards moistened with distilled water. Perfectly healthy peas, so far as selection will determine, were planted in this soil in which the weevilled peas had been sown and also failed to produce good plants, while similar peas, placed in like conditions, save the previous occupancy of sand by weevilled peas, showed a comparatively healthy growth.

More than this, if in sterilized sand, watered with distilled water, peas be planted in pairs, namely, a weevilled and a healthy one touching each other, both seeds of each set will fail to produce good plants. Healthy seeds again planted in the same soil developed a rank bacterial decay and a total failure in germination. One of the leading features of the study of peas was the secondary sprouts that were sent up after the primary one had become decayed by the Pythium or bacteria or both. Figure 30 shows the condition of several seedlings, four of which may be seen to have a second growth of stem, while in the others the germ is too far gone for any further growth.

The conclusions seem clear enough that the weevilled peas are not only in themselves a source of loss in the seeds, but in seeding they are the means of propagating a decay in other peas that would naturally grow.

Pea plants that have been struggling in the soil in the garden were removed and examined carefully, first washing away the loose earth. It was found that the root system, including the large and the small fibrils, contained uniformly a growth which, as far as can be determined, is a species of the potting-bench fungus, or the so-called "damping off," namely, Pythium and most likely *P. De Baryanum.*

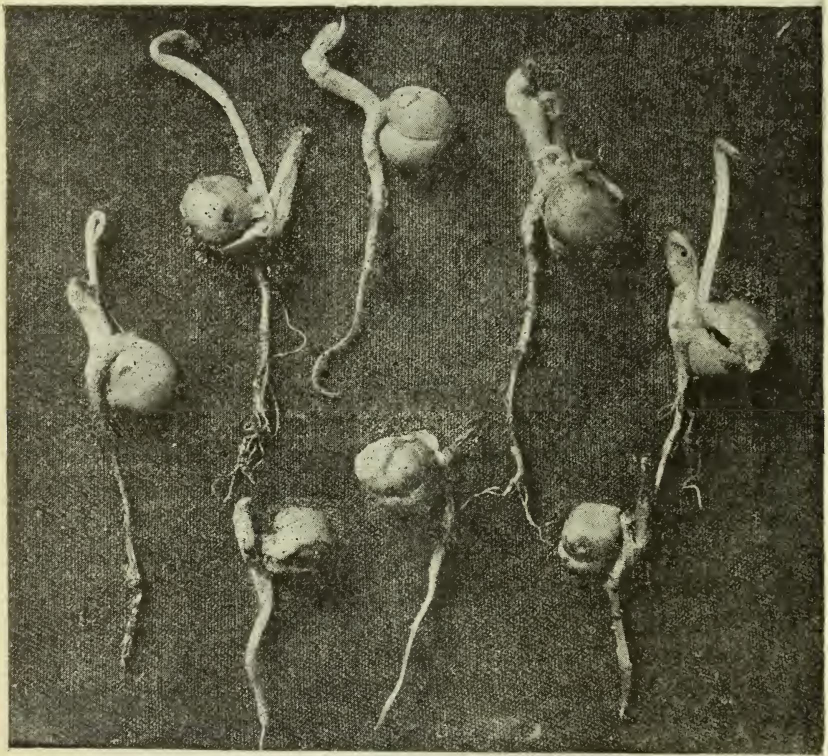

Fig. 30.
Bacterial disease of seedling peas.

In order to determine something further with regard to the development of this Pythium, peas have been grown under several conditions —those in the garden soil, as before stated, uniformly show the presence of this fungus; those grown in earth in pots in the laboratory likewise the same, and also peas germinated between folds of cloth upon a plate. It would seem that in addition to the bacterial trouble

starting in the weevilled peas and spreading from them to the others, we havs this subterranean fungus, namely, the Pythium, which is very abundant, and doubtlessly may be charged with considerable of the destruction of the crop.

In addition to the above-mentioned troubles there is a third which shows itself upon the young leaves. This is one of the leaf blights, and has not been credited with doing serious damage to the peas in this country. Its first appearance is in the form of blighted patches of the young leaves, but the whole plant is apparently infested with the threads of this parasitic fungus. The attacked foliage turns to a sickly yellow before becoming brown, large spots appear upon the vines and the plant fails to attain its normal development. An examination determined that this fungus, previously mentioned (*Ascochyta Pisi*, Leb.), is not confined to the foliage and vines; but the pods become very much spotted with the same disease, as shown in Figure 31. These pods, in their appearance, resemble very much the so-

Fig. 31.
Pea-pods affected with blight.

called pod-spot of the bean, and might be easily mistaken for the same trouble. In the field where the experiments have been carried on, the total length of rows devoted to the peas being one hundred and fifty feet, there was not a single pod which obtained a length of more than an inch, and of course was of no account. These pods, usually containing no seeds and averaging less than an inch in length, were uniformly more or less spotted with the Ascochyta.

Further investigations of the peas grown have brought to light the fact that the seeds themselves, apparently healthy when placed in the ground, soon show patches and spots of a dark color, which are also the spore-bearing places of the same Ascochyta as in Figure 32, which

is a magnified view of two peas. Therefore, it has been shown that in this third disease, which is strictly parasitic, the fungus is present in all parts of the plant excepting, possibly the root system, and including the seed itself from which the plant has grown, and possibly from which the fungus itself has spread and brought ruin.

There is still a fourth form of fungus development associated with these diseased pea-plants. It is found upon the surface of the peas after they have been in the ground for about a week, and the first leaves are obtaining some size. The appearance consists of small,

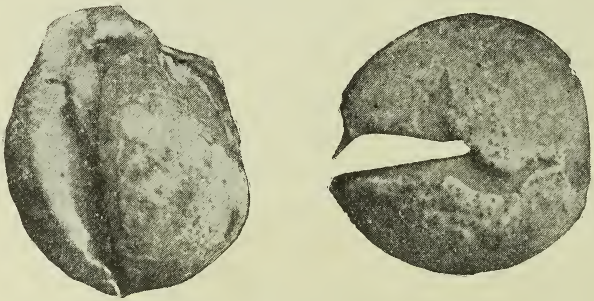

Fig. 32.

Peas affected with blight.

irregular, dark-olive patches upon the surface of the seed-coat. The earth adheres very closely to these patches, and it is with difficulty that they may be sufficiently cleaned to be fit for study. Just how much damage this fungus does is still an open question.

A Fatal Disease to Truck Crops.

Early in the spring specimens of egg-plant, tomato and other plants were sent me by Professor Rolfs, of the Florida Station, with statements to the effect that "for a number of years there has been in Florida a disease of egg-plant and of tomato to such an extent that the growing of the former has been almost entirely abandoned and that of the latter seriously interfered with." Having paid some special attention to egg-plant diseases in our own State and made a visit South to study the tomato blights, the writer was more than usually interested in this complaint of Professor Rolfs, from Florida.

A glance at the specimens suggested a complaint made to me in April, 1891, at New Orleans, by Dr. Stubbs, Director of the Louisiana Experiment Station, of a failure of his lupin plants in test rows to thrive. Specimens of the sick lupins when placed in a moist chamber quickly developed a rank growth of blue mould (Penicillium), soon followed by numerous small spherical bodies about the size, shape and color of mustard seeds. The Florida specimens showed no signs of the blue mould, as it is ordinarily understood, but they were almost literally covered with the "mustard seed."

Laboratory Cultures.

The first cultures of this fungus were with fresh tomato stems washed and seared in a flame. They were placed in a pile after inoculation, and with a moist cloth over all were confined under a bell-jar.

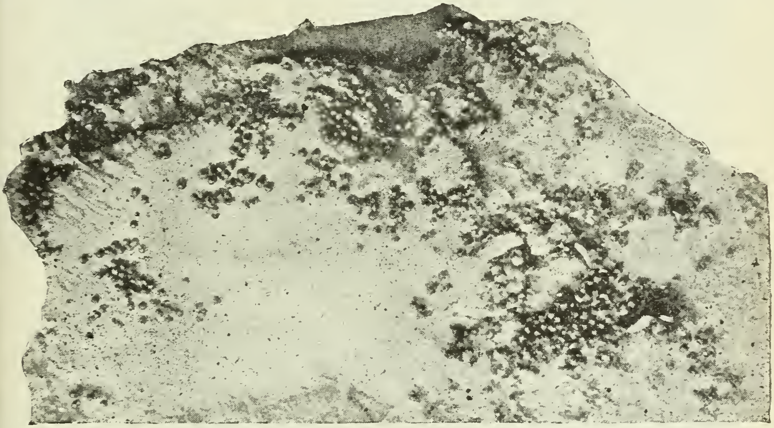

Fig. 33.
"Sclerotia" of blight.

The white, silky threads soon began to develop, and at the end of forty-eight hours had grown through the cloth. By the end of the fourth day minute specks could be detected in the rank, silky growth. These rapidly increased in size; their color changed from pure white to a cream yellow and finally to a dark brown when the spherical bodies were fully grown, and quite uniform in size. These were the "mustard seeds," or the sclerotia, as they were called by Professor Rolfs, and are shown natural size in Figure 33, as they formed upon the cloth.

These cultures were followed by similar ones upon stems of cucumber, squash, corn, *Datura Stramonium*, *Asclepias Syriaca* and *Phytolocca decandra*, upon all of which the fungus grew vigorously. It also spread rapidly upon the fruit of the tomato, cucumber and squash and a plate culture of cooked potato. It did not relish raw potato so well, and in neutral agar and sugar-water practically no growth took place, while upon tomato agar, starch and yolk of egg it grew vigorously.

Open-air Cultures.

While the above cultures were progressing in the laboratory, inoculations were made upon plants growing in the garden. Those made upon large plants at a distance from the ground all failed, even when the inoculated parts were covered with a wet cloth. Large plants were next inoculated near the ground, with the surface kept moist with moss, but it was only when watered daily that an active growth took place. Even with all precautions, it required three weeks to destroy a squash plant, while the tomato lived on and ripened some fruit. In short, it was quite fully demonstrated that while in Florida this fungus can be a destructive enemy to garden crops, with us it is only with almost constant attention that it can be made to even grow at all upon live plants in the garden. This would lead, naturally, to the conclusion that in our climate there may be little to fear from this enemy which is so troublesome farther south.

A Study of the Fungus.

Having failed to develop the blight to any serious extent upon growing crops, attention was next directed to a study of the fungus, and particularly with a view of determining the nature of the "mustard seed" bodies. The reader will bear in mind that the specimens, as received from Professor Rolfs, showed no signs of anything more than the colorless mycelium and the spherical bodies. Several of the first bell-jar cultures were allowed to become partially dry for ten days, and in these, when kept moist for several days after all the spherical bodies had matured, there was developed a blue mould. Spores of this Penicillium were transferred to sterilized squash stem test-tubes and a pure culture obtained, abounding in the conidial form of the mould. This was repeated with similar results,

but in no instance was there any development of the spherical bodies from them.

A culture of the silky mycelium, on which the "mustard seed" naturally forms, developed the conidia of the Penicillium upon yolk of eggs after nine days, but no spherical bodies ever formed in this culture.

There is no difficulty in sowing the spherical bodies upon nutrient substances and obtaining the rank growth of silky mycelium, to be

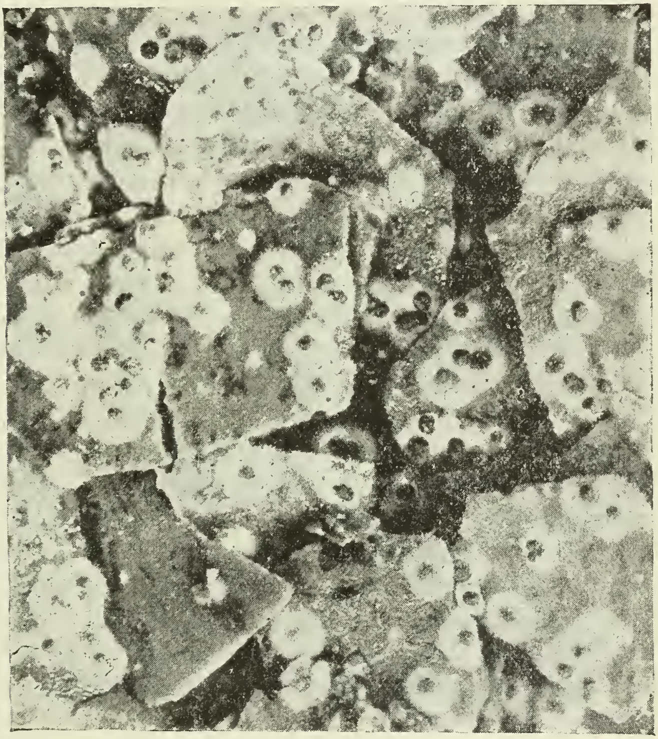

Fig. 34.

"Sclerotia" with young penicillium.

followed by a profusion of fresh "mustard seed." In two cases the bodies were similarly sown upon sterilized sliced potato, and, while failing to produce the white, silky mycelium, there developed a rank growth of the Penicillium from every spherical body. This is shown

in Figure 34, and before the mould spores began to form. The whole surface of the slices of potatoes became uniformly covered with the blue Penicillium.

The study of this subject is still in progress, under the immediate charge of Mr. J. A. Kelsey.

A Field Observation Upon Fruit Decays.

In 1892 a study was made of the fungous diseases of quinces, and the results were published in Bulletin No. 91. In the course of this bulletin it was stated that "A large apple tree stands in the orchard, surrounded on three sides by quince trees. The fruit, not the best, is permitted to drop and accumulate upon the ground in midsummer, it being an early autumn sort. These fallen apples were this season badly infested with the Sphæropsis, and the same was often the case with the fruit upon the tree. It was a noticeable fact that the quince trees that were close to this tree, some of them almost under it, were the most severely attacked. While there was no actual transfer of the infection by artificial means to demonstrate the fact, I am quite willing to hold the opinion that the quince fruit received the germs of the decay from the apples that were rotting by the bushel only a few feet away. That the decay should begin at the blossom-end, it is not unexpected, for there the spores, and the water causing them to germinate, would naturally lodge. The growing filaments of the spores would there find an easier entrance than elsewhere, because of the adhering floral parts. Near by, and with branches interlocking, stands a pear tree, and the fruit was quite badly infested with the Sphæropsis. Similar trees further away from the apple tree were less troubled with the decay, which only strengthens the opinion that all three kinds of fruit are naturally susceptible to the same infection, and the germs pass from one to the other through the air or by means of the various insects that visit the fruits, especially those with broken surfaces due to partial decay. The inoculations that were made in the laboratory seem confirmed by observations in the orchard. If the assumption holds, and it appears to be a sound one, it follows that the apple tree is a source of Sphæropsis infection for the quince and pear. The apple bears comparatively worthless fruit, and the quinces are the most valuable of all in this instance."

On July 17th, 1893, a visit was again made to this orchard, and while no decay was manifested among the quinces and pears, a fact was obtained that confirms the view held at the close of the investigation last season. The apple tree was loaded with fruit, and, for the most part, green and free from any rot; but upon one side was a good-sized limb, a graft of the Red Astrachan variety, also loaded with fruit, a large percentage of which was undergoing a decay. Over a hundred apples could have been gathered from the ground under this branch that were more or less decayed, many of them entirely rotten. Some of these fruits were brought to the laboratory and microscopically examined, the Sphæropsis being found on the specimens, as was expected.

It will be seen that by this observation the enemy is traced back one step further. Last season the source of the quince and pear infection was tracked to a single tree, the fruit of which was an early autumn sort. Now, in the middle of July, the black rot is confined to one branch of the tree bearing early summer fruit, where the decay is rampant, and, without question, is the particular place of exodus of the decay to the surrounding trees. The trouble is assisted by the shaded position held by the Astrachan limb, it being a low one, and overtopped by higher branches of the same and other trees. The fruit is poor, partly because of the shade and the decay, and it is left to accumulate upon the moist earth, where the fungus propagates extensively and develops myriads of spores. Therefore the conditions favor, naturally the rapid multiplication of the enemy which later makes sad inroads upon the quince and pear fruit of the orchard.

In the bulletin it was recommended to lay the axe at the foot of the tree, but in the light of more recent observations it may be that the only action necessary is to remove the branch which bears the early summer fruit, for in this the decay begins its season's work, and from which it reaches out in all directions to cause destruction.

Decays of Mature Apples.*

It is the purpose here to show some of the facts connected with the rotting of apples, realizing that what holds true concerning one kind of fruit applies almost equally well to others.

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* This paper first appeared in "The Popular Science Monthly" for May, 1893.

Let us, in the first place, take a survey of the normal subject, or, in other words, of a healthy apple. It is made up of five seed cavities, which occupy the central portion of the fruit and constitute the core. Outside of this is the edible portion, called the flesh, consisting of cells of small size filled with liquid substances. A tough layer covers the outside, which is the skin, and bears the coloring substance that determines whether the apple is green, red, mottled or striped. At one end of the fruit is the stem, or, as found in the barrel, this former means of attachment to the branch of the tree may have been broken away or pulled from the fruit—a matter of no small consideration when the question of decay is concerned. This end of the apple is known to the horticulturists as the "cavity," and varies greatly in different sorts, sometimes being deep and narrow, as in the Winesap and Pearmain, and broad and shallow in the Greening and Peck's Pleasant.

The opposite end of the apple bears the name of "basin," and contains the remnants of the blossom—sometimes called the eye of the fruit. This part of the apple is likewise deep in some varieties, and shallow and open in others. This is the weakest point in the whole apple as concerns the question of the keeping quality of the fruit. If the basin is shallow and the canal to the core firmly closed, there is much less likelihood of the fruit decaying than when it is deep, and the evident opening connects the center of the fruit with the surface.

For its own protection the perfect apple has a continuous layer of skin over its whole surface. The stem has not been removed from its cavity, but remains of its full length, for there is a place naturally provided for its separation from the branch which bore it. Such an apple is the rare exception, as found in the barrel. At the market or in the store-room of the consumer, instead of being without blemish upon the surface, there are small specks as large as a pin-head, or smaller, which dot the skin in patches. A portion of the surface of an apple with these specks is shown three times magnified in Figure 35. Sometimes one needs to look for a long time to find a fruit entirely free from these specks. Under the compound microscope these dots are resolved into a thin layer of interwoven threads, with their free ends radiating from a central point. This is one of the low forms of plant life belonging to the moulds, and grows from microscopic cells called spores, which in the economy of the moulds serves

he purpose of seeds. These spores are produced in great abundance, nd, being carried by the air, alight upon the fruit and there germinate nd grow into a colony or speck, which is all the time feeding upon he substance obtained from the skin of the apple.

The second defect in apples, as seen in the barrel, is the one known o fruit-dealers as the "scab." To the eye this is recognized by the ough-coated patches, often circular in outline, that are present upon he skin. There may be several of these spots, and, by their borders ecoming confluent, one-half or less of a fruit may be thus rough-oated and more or less dwarfed, making the apple onesided. This cab is due to a mould, which, under the microscope, is as different in s real structure from the specks above mentioned as the two are

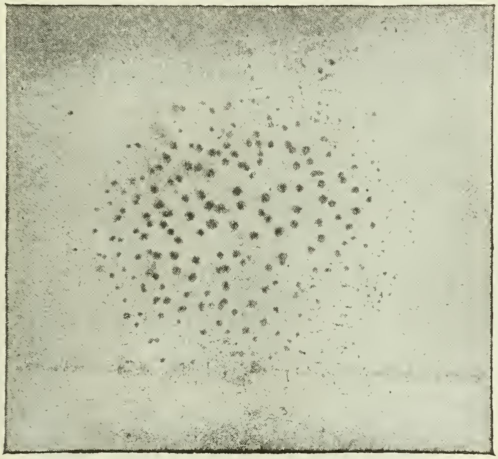

Fig. 35.

Apple specks.

nlike in general appearance. The botanical name of the species of ould causing the apple scab is *Fusicladium dendriticum*, Fl. It is s much a distinct kind of plant as the apple tree upon which it hrives. It is not confined to the fruit, but grows luxuriantly upon he foliage, causing it to become blotched with the brown patches and therwise destroyed. The mould consists of fine, cobwebby threads, hich penetrate the leaf and rob it of nourishment, and after a time orm patches upon the surface, where innumerable spores of a dark olor are produced.

The apples are first attacked by the scab fungus when they are quite small, probably while the tree is in blossom, or shortly after. At that time the surface of the young fruit is tender and has no well-developed skin, which, when the fruit nears maturity, might be so tough as to prevent the entrance of the scab mould. This, therefore, is a defect that does not come upon the fruit after harvest, and usually does not spread much after the apples are in the barrel.

The knowledge of the fact that the scab is due to a mould that begins to infest the fruit in early summer has led to experiments in spraying the trees during the growing season with the Bordeaux mixture and other fungicides, with marked success in checking its ravages. Trees sprayed three or four times in May or June have borne abundant fruit, comparatively free from scab, while unsprayed trees, otherwise

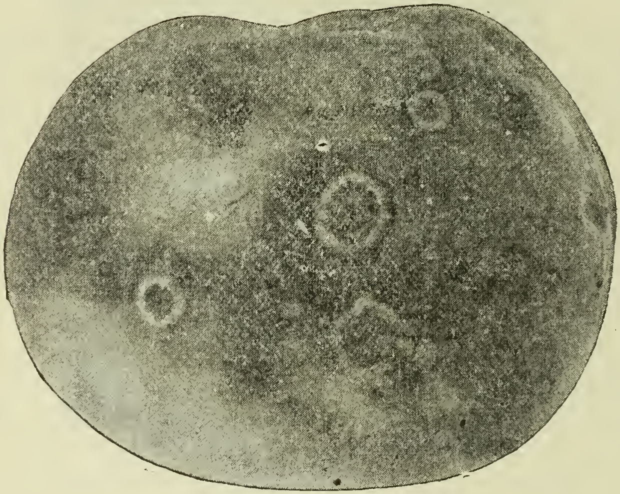

Fig. 36.
Apple scab.

alike, yielded a scant amount of distorted, scabby, withered apples. Figure 36 shows an apple that is a fair illustration of the working of the scab fungus.

One of the most interesting things in connection with the study of the decays of apples is the relation which one mould bears to another. There are several very common kinds of moulds, which grow nearly everywhere when circumstances favor them. Their spores seem to be almost omnipresent, but they do not possess the ability to penetrate

ugh substances, and the natural skin of the apple is usually a barer they cannot pass. Of all these moulds the *Penicillium glaucum*, k., or commonly known as the "blue mould," is the one that causes e greatest destruction in the store-room. A large part of the rapid ft rot is due to the Penicillium.

In a few words let the work of the scab fungus be reviewed. As e name indicates, it causes a scab upon the surface; the naturally-nooth, tough skin is roughened, and minute cracks are produced hich, in short, replace the ordinary skin, impervious to the blue ould, with a disrupted coat that furnishes both a fine lodgment for e spores of the mould and the condition favorable for their germi-

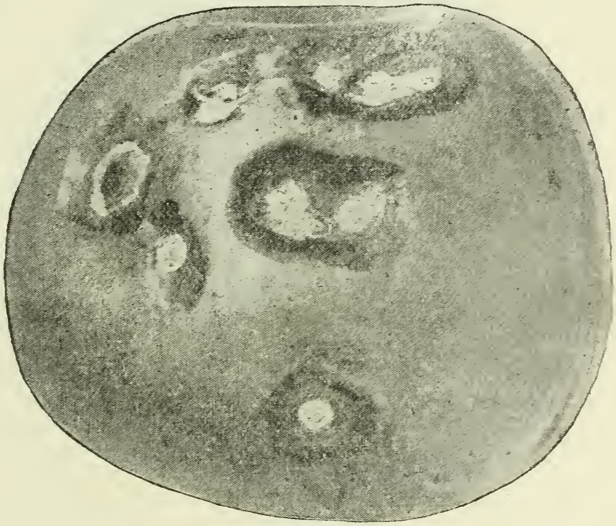

Fig. 37.

Apple mould following apple scab.

ition and the further rapid growth of the mould. It is easy to conive of the scab upon an apple being so light and superficial as not affect its real value, but the one defacement becomes the entrance a decay germ that in a few days reduces the whole apple to a oisome mass of rottenness, resulting in a million spores of blue mould. o prevent the soft rot of the apple in midwinter in the barrel the ees need to be sprayed in midsummer in the orchard, to check the evelopment of the scab that would otherwise furnish the place of itrance of the blue mould. Figure 37 shows an apple that, when

harvested, had a number of rough circular patches due to the scab fungus. When the photograph was taken each one of these spots was the seat of a rapid decay, due to the development upon them of the Penicillium, while all other portions of the fruit were in a normal condition.

There are many diseases due to those exceedingly minute germs, so widely talked of nowadays, namely, the bacteria. They attack animals and induce fevers of many sorts, and man sinks before them with the dreaded cholera, consumption, etc. Plants have their enemies

Fig. 38.

Apple blotch.

among these micro-organisms, and apples do not enjoy an immunity from them. The succulent substance of a ripe apple is a favorite food for the bacteria, the only check upon their abundant entrance being the tough skin. But there are too many weak places, and it is presumable that these germs, when falling upon them, are capable of beginning their course of rapid multiplication, which, when unchecked, reduces the fruit to rottenness. In Figures 38 is seen an apple under the apparently unbroken skin of which in several places were decaying spots with no signs of any other mischief-makers than the swarming millions of the micro-organisms. As soon as the skin becomes

oken in any such places, the coarser decay germs enter, and quickly e fruit is overrun with a motley vegetation of various moulds.

If we look further among the decaying fruits, it will not be long, ually, before an apple is found that does not agree with any of the scriptions given above. Perhaps it is healthy in all parts save one, d that has no scab present. The blue mould is absent, the skin is broken, except in a peculiar, almost regular manner. There is an ident central point where the fungus started, and, as it has spread, merous pimples have formed just under the skin, and sometimes in centric circles. From these minute light-colored pimples spores ze out and are ready to find their way to some other specimen.

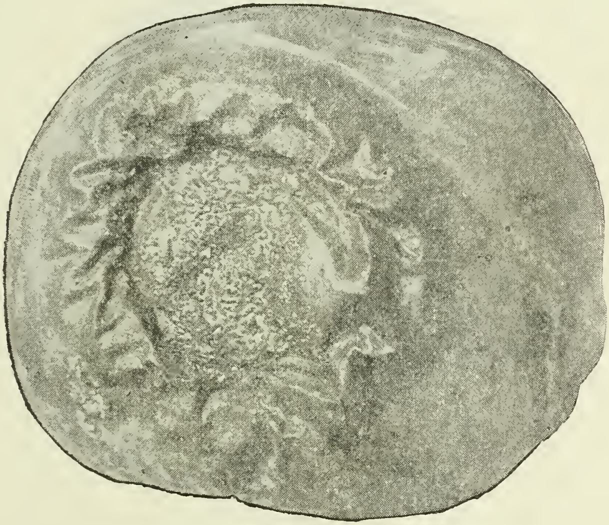

Fig. 39.

Apple bitter rot.

e affected portion of the apple has a bitter taste, and, on account of is, the term "bitter rot" has long been given to this form of decay. e same fungus causes the rotting of the grapes, and, if all the facts re known, this *Glœosporium fructigenum*, Berk., might be definitely arged with a large percentage of the decay of other fruits. An ple badly affected with the bitter rot is shown in Figure 39, but e regrets that many of the details are lost in the photo-engraving ocess by which the engraving was made.

This form of rot, while it may be met with upon the tree or in the

windfalls beneath it in late summer, is most abundant in the storeroom and is decidedly contagious—that is, an apple that is decaying with the bitter rot is able to communicate the decay to other fruits by means of the myriads of spores which are borne upon the surface of the ruptured pimples. These facts suggest the precaution of discarding any rotting fruits whenever found. There is little room for doubt that were the harvested fruits themselves sprayed with a fungicide it would aid materially in preserving them. Thus, if a thin coating of the Bordeaux mixture was applied, the spores of bitter rot and other decay germs would not so readily germinate. But there is the

Fig. 40.

Apple black rot.

objection of having the beauty of clean fruit lost under a film of fungicide that, while not particularly poisonous, is decidedly unpalatable, consisting of lime and sulphate of copper. A sensation was created in New York two years ago because grapes were thus marketed, and the same process for stored fruit is not here recommended, although its effectiveness as a preservative is granted.

A decay that might be mistaken for the last-mentioned is caused by a fungus of a widely-separated order. It is shown in Figure 40. This might be called the black rot, as it has a strong tendency to turn

e affected portions of a dark color. One of the characteristic features is the almost black pimples formed in considerable numbers neath the skin, which they finally rupture and then discharge large umbers of dark-olive spores. This fungus is a described species aring the name *Sphæropsis malorum*, Pk. It may be seen in early ples before they begin to ripen, and the windfalls, as they lie upon e ground, become badly infested with the Sphæropsis. It is not nfined to the apple, but thrives destructively upon quinces and ars as well. This decay, in its habits of growth, calls to mind the ct that the basin is the weakest point of fruits like the above-mentoned, for in most instances the black rot begins at the free end, here the remnants of the flower may be still adhering, and very kely assist in the fungus gaining a foothold. This decay, like the tter rot, is amenable to treatment, and therefore, in order to check destructive work in the store-room, the fungicide needs to be plied while the fruits are growing upon the trees. Thus, the work the prevention begins a long time previous to picking—while the rrel-staves are possibly still in the living forest tree. This reminds e of the time when the boy's education should begin, as stated by r. Holmes, namely, with his grandfather when he was a small lad.

Up to this point, remarks concerning the mechanical treatment of ples have been purposely withheld. There is no question about e importance of, so far as possible, preventing the bruising of the uit, From what has been said in strong terms concerning the barer of a tough skin which Nature has placed upon the apples, it goes thout saying that this defense should not be ruthlessly broken wn. It may be safely assumed that germs of decay are lurking most everywhere, ready to come in contact with any substances. A uise or cut in the skin is therefore even worse than a rough place used by a scab fungus as a lodgment provided by the minute spores conditions for moulds to grow. An apple bruised is a fruit for the cay of which germs are specially invited, and when such a specien is placed in the midst of other fruit it soon becomes a point of fection for its neighbors on all sides. Seldom is a fully-rotten ple found in a bin without several others near by it being more or s affected. A rotten apple is not its brother's keeper.

The surrounding conditions favor or retard the growth of the decay ngi. If the temperature is near freezing, they are comparatively active, but when the room is warm and moist the fruit cannot be

sxpected to keep well. Cold storage naturally checks the decay. The ideal apple has no fungous defacements and no bruises. If it could be placed in a dry, cool room free from fungous germs, it ought to keep indefinitely until chemical change ruins it as an article of food. But the facts in the case are far different from this ideal. The apple when gathered from the tree may have the germs of decay already within its tissue. They may have extended through the basin, become firmly located in the ragged remnants of the flower or by means of some insect or "worm" that has bit or burrowed the fruit. Its stem may have been broken close to the fruit or pulled out from it, or over the surface specks and scabs may have formed during the season of growth that have so destroyed the skin as to furnish a ready entrance for other more destructive germs. Bruises of the pulp and breaks in the skin expose the soft, highly-decomposable flesh to the "seeds" of decay, and as one contemplates what an apple is made of

Fig. 41.

Mouldy apple

and its many enemies, it seems almost a marvel that fruit keeps at all until it is cooked to kill the germs within it and then canned to prevent the entrance of those that are without. It is not designed that apples in their natural state should keep for long, and all attempts to preserve them in the fresh condition through the winter and far into the succeeding spring are a triumph against nature only to be won by the person who is conversant with the methods of his microscopic oppo-

nents. The use of fungicides in the orchard while the fruit is growing will insure more and fairer specimens, thus filling a larger number of barrels with apples that are less subject to attack after harvest. This, with careful handling to avoid bruises when picked and housed, together with a dry storage-room, should all bring a full reward. Figure 41 shows an apple in the last stages of dissolution, overrun inside and out with a diminutive forest of fungi. It is the seedtime, so to speak, with the host of species each vying with the others for the last particle of the apple, the seeds only being left behind ready to grow into trees when suitable circumstances obtain, provided the vital spark does not expire before the favoring conditions arrive. The pulp that has been destroyed is largely man's product, developed by him through long years of selection and culture, and for which the orchard is planted and preserved. Nature wants more apple seed; man desires more and better pulp. Nature claims that the pulp of the wild apple is only to secure the wider dissemination of the seed, and to the orchardist, middleman and consumer she speaks in her emphatic way that if you would exact of me extra-fine pulp, you must at the same time employ the best devices of your high civilization to preserve it from your omnipresent and active competitors, the insidious germs of decay.

Blight of Ornamental Spurge.

The cultivated spurge, *Euphorbia Myrsinites*, which Nicholson, in his "Dictionary of Gardening," states is "A very ornamental, hardy prostrate species," is a victim to a fungous disease to such an extent that its culture is becoming a questionable matter by the propagators of hardy perennials for yard decoration.

The most common point of attack is the flower cluster, so that the plant may flourish for a portion of the season and then be stricken down at the time when it is becoming most ornamental, and soon presents a most forlorn appearance. The disease rapidly passes down the stem from the flower cluster, and the thick, lead-colored leaves fall away, leaving the naked, blighted branches.

The accompanying engraving (Figure 42) gives the appearance of some of the stems. In the center of the picture is shown a healthy stem with two branches upon each side that have been defoliated by

the fungus. These stems also show that they have become much shrunken in the upper half.

The blight is due to an anthracnose of the genus Glœosporium, and is, therefore, a member of a group containing many of our worst plant enemies. One only needs to mention bitter rot of apples and grapes and closely-related members causing much destruction to

Fig. 42.
Anthracnose of garden spurge.

tomatoes, peppers and other garden fruits, to bring conviction that the spurge blight is a first cousin to a long line of anthracnoses, all members of the same genus.

This spurge disease is most likely a trouble that can be controlled if taken in time, but as the plant is not usually grown in any quantity

it may be the best plan to root out the spurge and set something else equally ornamental and less subject to blight in its place.

The species of anthracnose is apparently new and will be described in a botanical journal under the name of *Glœosporium Euphorbiœ*, Hals.

Fungous Diseases of Cultivated Sedums.

There are two leading fungous troubles of the garden sedums. The first is confined to the foliage and causes dark circular blotches

Fig. 43.
Anthracnose of garden sedums.

upon the leaves. This is *Septoria Sedi*, West, and may infest certain plants so badly as to almost entirely defoliate them. The sedums, like many other succulent-leaved plants, readily drop their leaves when affected by enemies of this sort, and not infrequently plants may be found of *Sedum spectabile* and other ornamental species that have the stems naked nearly to the tips of the branches. In fact almost as soon as the Septoria spots make their appearance, the leaves fall from

Fig. 44.
Enlarged view of anthracnose of sedum.

their attachment, and may be found upon the ground in great numbers where the fungus matures its spores, and from which the enemy is disseminated. It would be a preventive measure to gather the fallen leaves and burn them.

A second fungous disease attacks the plant usually at the insertion of the leaf, and afterwards does its greatest damage in the stem. There

is first a softening of the outer portion of the succulent stem and a manifest shrinking of the same. A stem when attacked midway of the top and base will soon lose its leaves, the fungus spreading throughout the whole, but more slowly downward to the base.

Soon after the shrinkage of the stem there appears upon the surface a multitude of dark specks, which are the fruiting points of the fungus, at which vast numbers of crescent spores are produced. The fungus is *Vermicularia Telephii*, Karst., recorded recently for Finland.

A plant with several of its stems killed by the fungus is shown in Figure 43. The specimens from which the engraving was made came from a pile of many hundred discarded plants that a commercial grower of this ornamental plant had rooted out from his beds. An enlarged view of two stems, showing the downward progress of the parasite, is given in Figure 44. The spore-bearing patches are plainly shown.

On account of the large, strong root system, remarkable for its vitality, the sedums are able below ground to withstand the inroads of the Vermicularia, and continue on from year to year; but probably a plant that is badly infested one season will continue to be the next unless care is taken to remove all old stems and burn them.

Hollyhock Diseases Again.

There are several fungous diseases of the hollyhock (mentioned in previous reports of this Department), and between them all, this old and popular perennial ornamental plant is a sorry sight in most places. One of the latest destructive comers is the hollyhock rust (*Puccinia Malvacearum*, Mont.), which during the past three years has spread with remarkable rapidity and fatality. This genuine rust, of the same family of fungi as that of the wheat and beet and carnation, causes the orange blotches upon the leaf and leaf stalk, and, in the worst cases, upon the whole stem.

A fungus that is a good second to the rust is the hollyhock leaf spot (*Cercospora Althæina*, Sacc.) It is widespread over the country, and may be known by the peculiar dark, angular spots which it causes in the affected leaves. These spots may be small and distinct at

first, but soon they become confluent and the leaf breaks up in large patches.

Figure 45 is a solar print engraving of a badly-affected leaf, and the light centers of the dark spots show where the leaf has become thin and lost all its original color, or the tissue has entirely disappeared. This trouble begins quite early in the life of the plant, for the writer has seen many hundreds of seedlings that were suffering severely from the leaf spot, and were not worth anything. The

Fig. 45.
The hollyhock leaf spot.

spores of this fungus are long and slender, like candles in shape, and are produced in great numbers upon the surface of the spots.

A third form of fungous disease of the hollyhock is shown in Figure 46. To the ordinary, untrained eye, this is at once seen to be widely different in its effect from the leaf spot shown in Figure 45. This may be known as the hollyhock leaf blight (*Phyllosticta Althæina* Sacc.) This parasite works more thoroughly than the leaf spot, in that it spreads from a center of infection and destroys the leaf almost

entirely as it goes. Thus there may be but one or two points where the germs found entrance, but from such points the disease works its way through the whole leaf. The engraving is of a leaf that has two such spots, one much larger than the other, and having already produced a large and irregular hole.

There seems to be no sort of hollyhock that is exempt from these diseases, so that very little can be done in the line of selection of the blight-proof sorts.

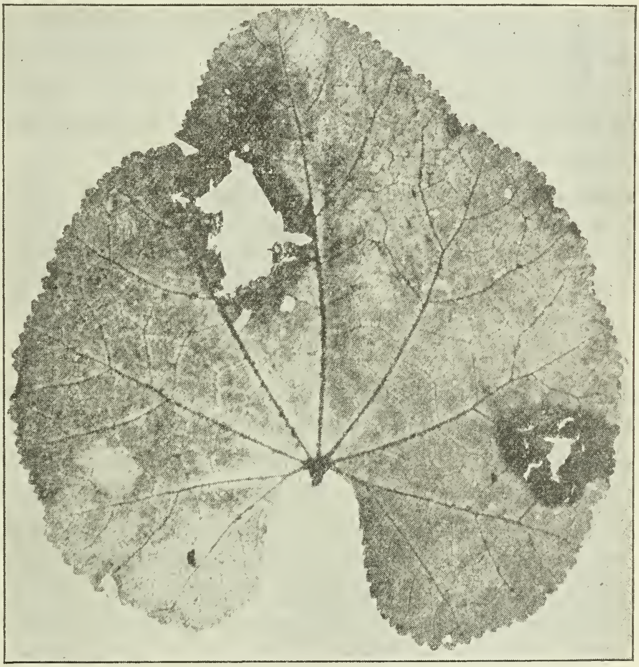

Fig. 46.

The hollyhock leaf blight.

In the first place it is important to have seed that is strong, and, if possible, from plants that are not affected with the rust and blights. If the seedlings become spotted or rusted, they should be cast out, for young plants do not, as a rule, overcome these troubles. Some good can be done to old plants by spraying them with the Bordeaux mixture, at least once a week, during the growing season. Unless something is done, hollyhock-growing will be a lost art in this country.

Some Fungous Diseases of the Carnation.*

The leading trouble under the above heading is the carnation rust (*Uromyces Caryophyllinus*, Schr.) This has been fully considered in the meetings of the American Carnation Society, the florists' and gardeners' journals and previous reports of this Department. It only need be said in passing, that the predictions are more than fulfilled, in that the rust has widened its range greatly during the last twelve months. A large number of rusted specimens have recently been received from various parts of the country. It is doubtless a much-dreaded enemy to the carnation-grower, and the greatest care should be taken to not introduce the rust into the green-houses in plants from other localities. And it goes without saying that only stock absolutely free from the rust is suitable for seedlings.

There are several diseases of the carnation of fungous origin besides the rust, and the first to which attention is invited is the so-called leaf spot.

The Carnation Leaf Spot.

(*Septoria Dianthi*, Desm.)

Carnation-growers recognize the work of the leaf spot fungus by the light-brown patches upon the leaf, and frequently the stem is in like manner affected. It is not confined to any one portion of the plant, but upon the stem it is most frequently noticed midway between the joints or parts of leaf insertion. It is more abundant in the lower than in the upper half of the leaf, and is particularly frequent upon the broad sheathing base of the leaf. The leaf that is troubled with the spot fungus often becomes contracted at the affected part, and usually the upper portion bends downward at this weakened place. A leaf with a dozen spots may have several bends downward and some sidewise, and a whole plant thus badly diseased presents a distressed appearance indeed. Besides the brown and lifeless area without definite size or outline which the fungus produces, there is a development upon the brown spot of a multitude of minute, almost black specks. These can be seen with the naked eye upon an old spot, but with a hand lens they are counted with ease.

These dark pimples consist of the microscopic threads of the

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* Read before the Pittsburgh meeting of the American Carnation Society, January, 1893.

fungus, so interwoven as to produce a minute flask buried beneath the surface of the carnation leaf and inside of which a vast number of slender, almost needlelike bodies are produced. These are the spores, and through an opening produced in the upper side of the cavity they ooze out when mature. They are mingled with a viscid substance, and when water is applied to the leaf this expands and pushes out of the opening as a semi-solid, and may then either become dissolved in the water or dry down into a hard mass, to be softened when more water falls upon the spot. This formation of the spores, and their exit, have a practical bearing upon the question of methods of applying remedies. While the spores are not developed superficially, they are poured out upon the leaf and at irregular intervals, depending upon the conditions that obtain upon the surface of the pimple. For example, if any pimple is filled with mature spores, the best way to induce a discharge of a considerable number of them is to add water. The spores thus brought to the surface are spread to other portions of the plant by the movement of the liquid, or when the water is evaporated the spores are left free to be carried to other parts of the house by currents of air. Which of these means is most effective in spreading the trouble is not known, but it would seem that the wet method is most favorable, and most of all when the plants are being watered with a hose, which throws the water with some force. It is easy to see that a spray playing upon a healthy plant through one affected with the spot, would quite certainly carry the germs along and leave them in the drops upon the former to germinate. This accounts, possibly, for the excess of affected spots at the base of the leaves, where water remains the longest, and therefore the conditions favoring the development of the fungus are greater than elsewhere. It is reasonable to conclude that it would, for example, be better to spray toward than from a diseased plant.

The Carnation Anthracnose.

There is a serious disease of carnations which may be characterized by the rapid manner with which it causes the decay of the affected tissue, and the profusion of spores produced free on the ends of radiating threads, which are intermingled with black, sharp-pointed hairs, arranged in microscopic rosettes upon the surface of the stem or leaf.

This fungus is especially fond of moisture, and therefore its range

upon the plant is not usually so great as the Septoria. While not confined to any one part, it is most frequently found upon the bases of the lower leaves and those portions of the stems that lie upon or are close to the ground. The upper leaves are not infested with this anthracnose, but they may be much enfeebled because of the decay caused by it in the stem below. Not infrequently one or more branches arising from near the ground may be badly anthracnosed, and the foliage above will in consequence be sickly in appearance and bear no blooms. More than any other fungus this one removes foliage and branches from beds that are allowed to grow as a thick mat, and have a wet bottom due to a lack of evaporation.

The greatest damage, however, is done by the anthracnose in the cutting-bed. It is not unusual for a propagator to lose 50 per cent. or even the whole of the sets. It seems quite probable that the filaments, unobserved, were in the stock plants and when placed under the new conditions of the sand-bed soon developed, and the cuttings began to decay at the base, and afterwards drop. Before the cuttings fall, the dark, almost black spore spots of the fungus might have been seen. This form of damping off is particularly contagious on account of the rapidity with which the spores germinate. By actual test cases of inoculation, fully developed spore-bearing spots have been produced upon healthy carnation stems in three days, when these stems were kept moist, as are portions of cuttings below and close above the surface of the sand.

Gardeners have frequently observed that some stock is much worse than others, which, in large part, can be accounted for on the ground that the fungus is not uniformly distributed in mature plants. It is scarcely necessary to add a word of caution here, so well known is it to propagators that only the best of healthy plants should be used as stock. Professor Atkinson, after a careful study in agar culture, concludes that this fungus is a member of the genus Volutella.

The Carnation Leaf Mould.

(*Heterosporium echinulatum*, Berk.)

Complaints have been made that a mould is damaging the carnations, and a study of this trouble has been under consideration. The disease shows itself on the leaves, often the younger ones, near the tips of the stems, and usually appears in nearly circular spots, varying

from a sixteenth to a sixth of an inch in diameter. In the worst cases, the whole leaf, and even the entire top of the plant, becomes mouldy. At first, the spot is of a pale, ashy color, and covered with a fine, dense growth of mould, but the color changes to a gray shade, sometimes approaching dark brown. The fungus is one of the many gray moulds belonging to the genus Heterosporium, and bears its multitudes of spores upon the sides of the filaments which come from the leaf through the stomata or "breathing pores," and afterwards branch in an irregular and profuse manner. The spores are borne above the surface of the leaf, and, when ripe, easily fall away, and become the means by which the infection is carried by water or air to some healthy spot, where a new point of infection may be produced. On account of the spores being produced free, that is, not inclosed in any wall, it seems probable that the fungicides would be quite effective with this enemy.

A Bacterial Disease of the Carnation.

Bacterial diseases are not easy to describe, and the one of the carnation, assumes many conditions, depending largely upon the stage in the progress of the disorder. The germ is exceedingly small and is only seen when the high powers of the microscope are employed. This low form of plant organism has no filaments so common to the leaf spot, anthracnose and moulds already considered, and therefore no conspicuous spore formation is to be found upon the surface. Attention is attracted to the victim by the manifest lack of vigor and the consequent failure to produce the usual growth and number of blooms. The peculiar rich light green of health is replaced by a yellowish shade which is not uniform in all parts. If an apparently healthy leaf from such a sick plant is held up toward the light, as between the observer and a window, many pellucid dots will be seen scattered throughout the leaf. These translucent dots vary in size from those that are seen only with a hand lens to the size of the head of a pin, and many become as large as a half dime. When small they are almost always circular and resemble the dots found naturally in the leaves of the common St. John's Wort (*Hypericum perforatum*). These dots are produced by the bacteria which, swarming in the cells, destroy the ordinary leaf green (chlorophyl), and by multiplying and passing to neighboring cells cause the enlargement of the spot until finally the diseased areas coalesce and the whole leaf becomes dis-

colored and dies. This discoloration is an interesting feature and one that may be used to detect the nature of the disease. In some plants, before the trouble has gone very far, the foliage will exhibit very marked spots of a conspicuous purple color. They seem to be one of the results of the action of the bacteria. As before stated, the first observable destructive action of the bacteria is upon the green granules of chlorophyl, and following this is the development of the purple color. As far as my observations go, this color is most conspicuous in those varieties with pink blooms. In the yellow sorts it has been noticed that almost at once the pellucid pits or dots assume a manifest lemon tint, and white sorts seem to be the least of all inclined to develop any color.

From the peculiar manner in which the bacteria begin the work of destruction at many hundreds of points, possibly, in a single leaf, it is quite natural to suppose that each spot has its origin in a single germ. The rate of multiplication is so very rapid that it is only a question of favorable conditions and a brief period for a million micro-organisms to swarm at any initial point.

It is natural to presume that the germs enter the leaf from the air, and the microscopic inspection of the young spots shows that ample provision is made for the easy entrance of the bacteria, through the vast numbers of stomata. The pores are favorably constructed for retaining these minute germs, being somewhat funnel-shaped, into which they may drop when the guard-cells are open. The microscope, more than this, demonstrates that the point of inoculation is at the base of a pore or stoma.

If these statements are facts and the bacteria of the carnation, coming from without, enter the plant through the stoma, and afterward breed destruction in the tissue in which they thrive, it follows that the remedy must be applied to the leaf-surface at the time when the germs are reaching the plant and effecting an entrance through the pores of the epidermis. It is very possible that spraying the plants with a fungicide will be able to do much to check the ravages of the bacterial trouble. Surely there is every reason to suggest an attempt to get control, for, from the nature of the enemy and the habit and anatomy of the victim, there is little hope of gaining ground by any process that involves hope without works.

Remedies for Carnation Troubles.

The point that most interests carnation-growers is that of the best way to hold the fungous enemies in check. The knowledge of the nature of the enemies is the first essential. If their habits are understood, a person is able to apply remedies that would not otherwise be suggested. These fungous troubles do not usually come into the plants through the roots and are not carried up with the sap. They enter from without by the pores, coming in contact with the surface of the plant and there germinating, sending their microscopic filaments into the victim. The rapidity with which this infection takes place depends upon the prevalence of the germs in that vicinity, in this instance a green-house, and the heat and moisture they obtain. Fungi, as a rule, are lovers of dampness and a good degree of heat. To reduce the number of germs of any disease of carnations in a house is a task of no small proportions. The ideal house contains no noxious spores, therefore no rusty, mouldy or blighted plants, and at the same time has the heat and humidity most desired by the carnations. It goes without saying that plants already worthless from fungous disease should be speedily removed. Care, as commonly understood, goes a great way toward warding off fungous disease. If all the conditions of soil, manure, temperature, sunlight, moisture, fresh air, and the like, are most favorable, the plants will naturally be strong, and therefore be better able to stand the inroads of the fungous enemies. Much depends upon the training of the plants that they be kept up from the earth, or otherwise the anthracnose will flourish because of the excess of moisture in the shaded and ill-ventilated portions.

But it is not my purpose to give instruction in these things only so far as they relate to the production and prevalence of fungous enemies. Let it be borne in mind that carnations are grown under conditions that are quite favorable to the diseases of the sorts above named, and any day a neglect of the strict rules of sanitation may be the beginning of decays for a long time to come.

After everything under the head of nursing has been planned for the plants, and while this is being daily carried out, there are certain direct remedies that may be employed. While these fungi are destructive, they are also quite easily destroyed by certain compounds which are harmless to the carnations. No substances have proved more effective as fungicides than the compounds of copper, and they are

adopted by orchardists quite generally in the better fruit regions of the world. There is no reason why the gardeners should not avail themselves of the researches of the experiment stations along these lines, and apply these compounds to the improvement of the plants of the green-house and ornamental grounds. Time will not permit the enumeration of the triumphs over the rot, mildew and other destructive diseases of the vineyard. Pears are again grown where their profitable culture had been despaired of, and apples, quinces, and, in fact, all sorts of fruits and many vegetables are grown successfully upon the ruins of former crops, because the spraying-pump is a regularly-adopted implement, and the application of fungicides as much a part of the work of the orchard as that of fertilizers.

There are many of these mixtures for the prevention of fungous diseases of plants, but the three that give the greatest promise are:

Potassium Sulphide Solution. Potassium sulphide, one ounce; water, ten gallons. The potassium sulphide is a solid, costing fifteen cents a pound, and is easily dissolved in the water as needed. In some cases it has been most convenient for me to dissolve the solid in a quart bottle, and ask the gardener to pour out the required amount as needed for use. The application is by spraying thoroughly about once a week. The results have been so marked that in one instance a large grower of carnations, after using this mixture for a season, wrote me that he felt confident that it had saved him a great deal, and that if generally used would prove a blessing to all who are affected with carnation diseases of the sorts above mentioned. Possibly it would be a benefit when rust is the leading enemy.

The Bordeaux Mixture. Perhaps the best fungicide now in use in orchard and garden is the Bordeaux mixture. This is made as follows: Copper sulphate, three pounds; lime (unslaked), two pounds; water, twenty-two gallons. Dissolve the sulphate of copper in one vessel and slake the lime in another, then mix the two and dilute to the required strength. This is the so-called half-strength Bordeaux mixture, which has during the past season proved equally effective with the full strength, in many instances, and for carnations will be strong enough. It is seen that this is a lime mixture and the foliage will be covered with a bluish-white layer. But it is to be remembered that this does not differ greatly from the natural color of the carnation leaf and stem, and it is one that can be quickly removed from the portion sent to market. A weekly spraying of the plants with this Bor-

deaux mixture should prove remunerative in houses troubled with fungous enemies. The Bordeaux mixture is inexpensive, the copper sulphate (blue vitriol, or bluestone) costing eight cents per pound.

The Ammoniacal Solution. A third compound that does not have the lime, and therefore gives the sprayed plants no marked coating, is the ammoniacal solution of copper carbonate. Its formula is as follows: Copper carbonate, five ounces; aqua ammonia (26), five pints; water, fifty gallons. The copper carbonate is first wet up with water into a paste and the ammonia slowly added until the solution becomes clear. This can be kept in a bottle, and the required amount diluted as desired for spraying. The carbonate of copper costs thirty-five cents a pound and ammonia sixteen cents a quart, and therefore enough for spraying a large house, weekly, is a small bill of expense.

Taking all things into consideration, it is probable that the three preparations above described are arranged in the order of excellence, the best being placed last.

If everything in the way of attention and care has been given to the carnation-bed, and spraying is practiced thoroughly and continuously, there is little doubt that the Divine Flower will repay the owner, literally, for all that has been put upon it. It belongs to a royal family, and needs to be treated in a kingly fashion; then will princes bow down and worship it, and queens traverse the desert to behold its crown.

The Mint Rust Upon the Variegated Balm.

At a commercial green-house recently visited, the writer was surprised to find a quantity of variegated or silver balm (*Melissa officinalis*) badly infested with the mint rust (*Puccinis Menthæ*, Pers.) This fungus is one of the most common and widespread of all the genuine rusts, having no less than thirty species of hosts scattered through the following and other genera, namely: Mentha, Thymus, Calamintha, Nepita, Cunila, Monarda, Hedeoma, the leading American host genera being Mentha, Pycnanthemum and Monarda.

As Dr. Burrill notes,* the American form of the species is markedly different from the European in the echinulate teleutospores. It is this *forma Americana*, as Saccardo styles it, that infests the Melissa.

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* Parasitic Fungi of Illinois, p. 190.

The host is an old-world species, and it is interesting to note that it has adopted the American style, so to speak, for its form of rust. The same is true of the *Mentha piperitæ,* (peppermint), the only other member of the mint family that the writer has seen badly attacked by the rust while growing under glass.

There is a large field for this rust within the green-house should it spread to one or more of a long list of members of the mint family. The coleus alone, in all its great number of popular varieties, might become a victim to *Puccinia Menthæ,* and possibly cause as much alarm among commercial and other gardeners as the rust of the hollyhock or of the carnation.

There seems to be no choice whatever on the part of the parasite between the etiolated and green parts of the balm leaves, so far as one may judge from the even distribution throughout of the rust sori. This is as might be expected, as the Puccinia is a deep, wide feeder throughout the tissues of the host, and fruiting is the last stage of its growth.

The books, Saccardo, Winter, Cohn, Burrill and others make no mention of Melissa as a host for *Puccinia Menthæ,* Pers.

Fungous Diseases of Ornamental Bulbous Plants.*

The lilies, which may, by right, take the lead among bulbous ornamental plants, have several leaf blights, among which are *Sphærella cinxia,* Sacc., *Phyllosticta liliicola,* Sacc., *Cylindrosporium inconspicum,* Wint., and *Cercosporella liliicola* (R.), Sacc. But it is among the rusts that we have more conspicuous and sometimes destructive species of fungi. Thus, upon lilies there may be *Uromyces erythroni* (DC.), Pass., with a wide range of hosts, from the Crown Imperial to the plebeian onion. *Uromyces lilii,* Clint., is a species found first on leaves of *Lilium candidum,* at Buffalo, N. Y., and might be called the American lily rust, to distinguish it from some of the others. Two species of cluster-cup fungi are recorded for the lilies, one *Æcidium Safianoffarum,* Thum., on the Martagon lily, in Siberia, and

* Prepared for and published in Allen's "Bulbs and Tuberous-rooted Plants."

Æcidium convallariæ, Schm., which flourishes upon a wide list of the liliaceous groups of plants. While this is by no means the full list of the fungi attacking the lilies, it suffices to show that there are many enemies, possibly the worst of which is to be mentioned later.

The hyacinth, in like manner, has several destructive fungi, among which are *Dictyuchus monosporus*, Seitg., closely related to the Pythiums, which are among the worst enemies known upon the potting-bench or in the green-house. *Rosellinia Massinkii*, Sacc., thrives upon the bulbs, while, perhaps, the worst of all is *Bacillus hyacinthi* (Wakk.), Trev., which is known as the hyacinth disease, and will be considered later.

The tulips have two species of the rust, namely, *Puccinia tulipæ*, Schw., and *P. Prostii*, Moug., both thriving upon the leaves. There is a smut, *Ustilago tulipa* (H.), Wint., of the tulip, as the specific name indicates. Not the least destructive, particularly to the bulbs, is a gray mould, *Botrytis parasitica*, Cav., which is closely related to the Brotrytis causing the trouble among lilies known as the lily disease.

The narcissus has a rust preying upon it, namely, *Puccinia Schrœteri*, Pass., that sometimes is quite destructive to the *Narcissus poeticus*. A rust upon the crocus is known to science as *Uromyces croci*, Pass., affecting the foliage in particular. The gladiolus has a rust, *Urocystis gladioli* (R.), Sm., upon its bulbs; a rust, *Puccinia gladioli*, Cast., upon the leaves, and several blights, as, for example, *Sphærella fusca*, Pass., upon the foliage. Enough has been given to show that the bulbous ornamental plants are not exempt from the fungous troubles that other cultivated plants are heir to.

Returning now to the lily disease, so called, we find in it an old destructive enemy. It has been studied extensively by H. Marshall Ward, who gives it a whole chapter in his work upon "Diseases of Plants." The same subject was investigated by Mr. A. S. Kean, formerly a student in my laboratory, in Bermuda, where the growing of lilies is a leading industry, and the disease is a serious menace. His results were published, with a large plate, in the "Botanical Gazette" for January, 1890. Professor Ward calls the lily disease one of the most annoying pests that the horticulturist has had to trouble him of late years. The disease first shows itself as small rusty spots upon the buds and leaves, and by their enlarging the blossoms

are ruined. Figure 47 shows the upper portion of a lily plant, with four buds badly attacked by the Botrytis fungus. This Botrytis consists of coarse threads, which run in all directions through the attacked branched stalks, bearing multitudes of spores. A magnified view of a section of the diseased tissue is shown in Figure 48.

This form of mould is common upon many plants, and at times is very destructive to root crops, as turnip and carrot. The onion, another bulbous plant, is often attacked by the same or a similar gray mould (Botrytis). The multitudes of spores borne upon the tips of the branches germinate quickly, and, when lying upon the surface of a lily leaf, will bore their tubes through the epidermis, as illustrated in Figure 49. When once inside, the thread increases in size and grows rapidly in length, branching and causing decay as it pushes along. After the Botrytis fungus has grown for a while it may produce dark, hard bodies, by a peculiar twisting and knotting of its threads. These dark masses, or sclerotia, remain uninjured through the winter, and when spring comes they produce peculiar trumpet-shaped outgrowths, as shown in Figure 50, which finally give rise to multitudes of spores. These are set free, and finding their way to the young lily, produce the destructive gray mould again. These spores, by their large numbers and quick growth, show how it is possible for the lily disease to spread rapidly. The Botrytis is fond of moisture, and in a dry season the lilies may generally escape, while if the weather is damp, the destruction may be great. Mr. Kean suggests as a remedy "the planting of some other crop in alternate rows, which, with high and spreading foliage, will prevent the col-

Fig. 47.

Portion of lily plant with disease.

ection of the dew upon the leaves and thus check the fungus, so ependent upon moisture for its propagation."

The hyacinth disease proper is ascribed to a microscopic organism, ylindrical in shape, and about four times as long as broad. Wakker, ho has studied this destructive disease extensively, named the germ *acterium hyacinthi*, and brief ccounts of the species may be ound in the leading books on acteriology, as in Sternberg, nder *Bacillus hyacinthi septicus*, age 651. The germs are, in appearance, almost identical with hose of many diseases of a congious nature among animals and an. This is only one of the any instances where a species of e higher plants is a victim to e ravages of one or more of the icroscopic organisms, also vegeble in nature; the sorghum ight and the fire blight of pears being two other examples. The yacinth bulbs that are affected with the above-named bacterium, hen cut through with a knife, show small pits filled with a yellow

Fig. 48.
Section of diseased tissue.

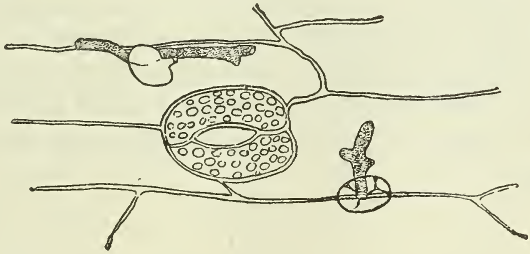

Fig. 49.
Entering of disease.

ucilage. It is in this slime that the micro-organism in question ounds. At the time of flowering, the diseased plants in the field ow yellow streaks in the leaves, prominent at the base, and disapparing toward the tip. In these yellow lines the bacteria swarm, in

a slime which resembles that of the bulbs. It will be seen that littl needs to be said of the description of the hyacinth disease, and ther is not much yet to write as to the treatment. A bulb that exhibit the yellow slime in cross-section, would, if set in the field, produce diseased plant. The nature of the malady is such that the applicatio of fungicides for sick plants, while not without hope, does not promis great things. Careful watching for the disease and rejecting affecte bulbs are the chief remedial agents.

There is a black rot of the hyacinth, also found upon narcissus and scilla bulbs, that is probably a first cousin of the lily disease, if not the same thing. It has the hard, dark masses, or sclerotia, and the other structures mentioned with the Botrytis (see engraving, Figure 50), and is probably *Sclerotinia* (*Peziza*) *bulborum*, Wak.

Fig. 50.

Sclerotia of hyacinth disease.

The gummosis, so called, of the hyacinth, also common to the tulip and ixia bulbs, has likewise bee studied by Wakker. The pure-white gum pockets are found mostl between the epidermis and tissue below, the starch being replaced wit gum by a process of degeneration. These gum-bearing cells may i crease abnormally in size. Wakker concludes that this gummos and the "white rot" of hyacinths are the same thing, and, havi failed to produce the abnormal condition artificially, by inoculatio affirms that there is no indication of the cause being due to a parasi of any kind. This last seems, therefore, a purely physiological on and there are many such among plants living under the pressure high culture.

Diseases of the Cyclamen.

Within the last few months complaints have come to me of serio trouble with the cyclamen. One large grower, for example, w obliged to throw away nearly his whole crop, having at present but few specimens, and they not in good health. This disease, so far as has been studied, is confined to the foliage; but it may, upon furth investigation, be found to infest the whole plant. The general a

pearance of the plant when infested with this fungous disease is easily described. Certain leaves, not necessarily the older and outer ones, turn of a dark color in ill-defined areas—that is, when a leaf is beginning to show the presence of this fungus, there will be a darkening of the most affected portion. After a while this diseased area will become dry and of a lighter color, and exhibit a number of concentric rings of light and dark bands. The leaf at this place is of course dead and brittle, and upon touching it, it may break away, so that irregular holes are frequently met with in the leaves. There is no one portion of the blade that is more subject to attack than another; sometimes the upper third of the leaf will be thus blighted, and the rounded tip curled under. Again, the blotch may be midway between the tip and the right or left lobe at the base of the blade. Some leaves may have two or more of these diseased areas, and when such is the case by the spreading of the trouble the leaf is soon entirely ruined.

This disease, which appears to be unrecorded in the works upon parasitic fungi, is a member of the genus Phoma (*P. Cyclamenœ*, Hals.), and from what has been said above it is strictly of a fungous origin, and must be treated as such. It remains to be determined if the corms and leaf stalks are also affected with this Phoma; but whether they are or not, it is evident from the knowledge of closely-related fungi upon other plants, that this pest of the cyclamen is amenable to treatment with the ordinary fungicides. If those who are troubled with this leaf blight, after removing all of the leaves showing the darkened and dead patches, should use either the Bordeaux mixture or the ammoniacal carbonate of copper compound, it would probably assist materially in checking the disease, and possibly eradicating it from the house.

The suggestion has come that it is the same as the violet disease. This does not seem to be probable. There are several diseases of the violet, and none of them, so far as the writer knows, has the microscopic characteristics of the Phoma of the cyclamen. As far as can be determined from the books upon diseases of plants, there is recorded only one other cyclamen leaf parasite, and it is quite different in its appearance to the unassisted eye from the Phoma above treated, and differs much more strongly when seen under the microscope. It is *Septoria Cyclamenœ*, thus far an European trouble.

Another trouble among the cyclamens is a decay of the crown, so

that the old leaves fall and the younger ones rot off before they have attained much size. After the leaves become prostrate upon the earth, and sometimes before, they are covered with a gray mould (*Botrytis vulgaris*), and at first sight to this fungus might be ascribed the cause of the whole trouble, while in fact it follows upon the ruins of some other active agent of destruction. While it hastens the dissolution of the plant, the Botrytis does not seem to attack healthy cyclamens. When plants thus ruined are examined the corm is found softened to an offensive pulp at the crown, or possibly in two or more places in addition, and in the worst cases the decay has spread throughout the fleshy "bulb." In specimens secured before the Botrytis has gained a foothold, bacteria are the only germs of decay present, and these, when transferred to a healthy corm, will in twenty-four hours inaugurate a new set of decay. While bacteria are probably the first micro or other organisms to make their appearance and start destruction of the tissue, it is more than likely that an antecedent is to be found in some minute mite or insect not yet discovered. This opinion is founded upon the obscured fact that plants from a collection when the bacterial trouble is rampant and still free from it have the leaves dwarfed and malformed in a manner to suggest to Professor Smith the work of some insect.

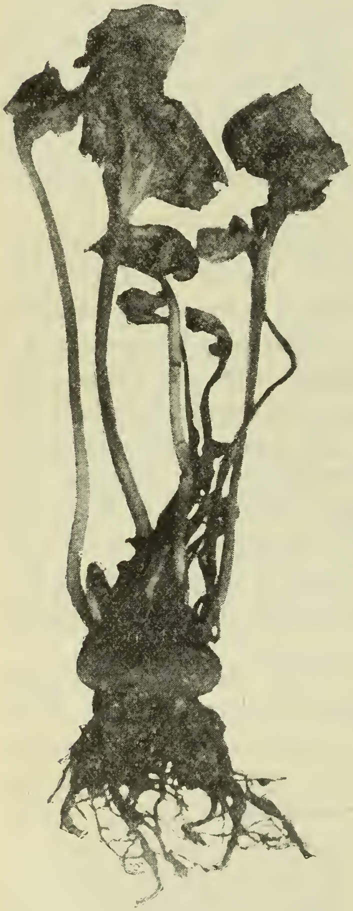

Fig. 51.

Bacterial disease of cyclamen.

It is a well-established fact that bacterial germs find access to plants through wounds, and thrive best when the resistant powers of the victim are reduced by previous sapping and mining of larger enemies.

It is possible, therefore, in this case that the best treatment for the bacterial decay is the application of an insecticide, as has proven true in some instances with a similar rot among violets.

Figure 51 shows one of the ruined plants fastened up by the corm and the decayed leaves held in place by pins for the photograph. A fourth fungous trouble, the phoma, bacteria and botrytis being the other three, is an anthracnose which works upon the foliage. Figure 52 shows the appearance of a cyclamen leaf that is badly anthracnosed. The fungus gains a foothold at certain points in the leaf and spreads from them in all directions until the whole pulp is destroyed. Cyclamen leaves are more than ordinarily well adapted for the reception of fungous diseases, for they frequently have one or more cavities in the upper side in which water may be almost constantly present, thus furnishing a supply for the germination of spores that may fall upon the foliage.

The appearance of the Phoma first treated and this anthracnose (*Colletotrichum Cyclamenœ*, Hals.) are so nearly alike without the microscope that the same engraving (Figure 52) answers for both.

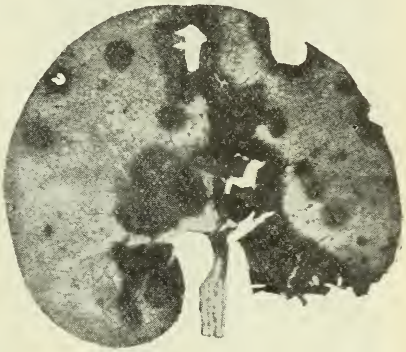

Fig. 52.
Anthracnose of cyclamen.

Diseases of Calla.

The calla, sometimes called "Lily of the Nile," "White Arum," "Trumpet Lily" and "Calla Lily" (*Richardia Africana*), is usually comparatively free from fungous diseases. However, in December last, specimens were sent from St. Louis, Mo., with the statement that the plants had been imported from California apparently in perfect health, grew luxuriantly, but shortly after blooming, decay set in, and the whole lot of a hundred quickly perished. Other roots from the same lot, but planted elsewhere, behaved in the same manner.

The decay began at the top of the crown at the insertion of the leaves. The engraving (Figure 53), made from a photograph of a longitudinal section of one of the diseased specimens, shows in its central darker portion the area of the decay.

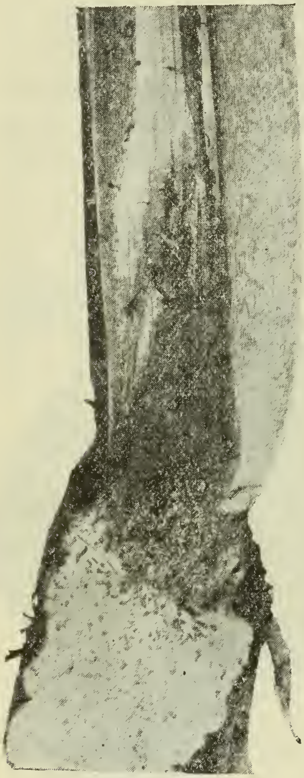

Fig. 53.

Bacterial disease of calla.

The only sufficient cause of the trouble is bacteria, which were found in great abundance in the disorganized parts. The individual germs were ellipsoidal, from 2–3 by $1\text{–}\frac{1}{2}\ u$ in size, and a member of the genus Bacterium.

An interesting point in connection with this outbreak of calla disease is that other plants, grown under similar circumstances, but not from the same lot brought from California, have thus far escaped, while those of the same importation, and grown at widely-separated places, have been similarly affected.

It is possible that the plants were all affected at the outset with the bacterial germs, or else there was some other primary cause of the disease, or predisposing condition that obtained before the importation was divided up among the several growers.

As a remedial suggestion, owing to the fact that the somewhat ligneous crown, below its succulent tip, does not give way readily to the bacteria, it is possible that the plant may be saved by cutting off the diseased upper portion and permitting new suckers to form that may possibly escape the disease trouble that destroyed the parent shoot.

The calla leaves sometimes become blighted with large, ashy spots upon which are minute pimples of a dark color. The fungus causing the loss of green in these areas is *Phyllosticta Richardiœ,* Hals. As this fungus is close of kin with many others of its genus, causing leaf spots upon various cultivated plants, little further need be said.

There is a leaf blight of the calla (*Cercospora Richardiæcola*, Atk.) found by Professor Atkinson, in Alabama, in 1891, but has not been met with in New Jersey.

There is a trouble complained of by gardeners of the edges of the leaves of their callas turning black in circular spots as shown in Figure 54. This blight is confined to certain plants, and appears to be the result of some functional defect, possibly of the roots. Whatever may be the primary cause, the result is a serious disfigurement of the plant.

Fig. 54.
Calla margin blight.

Upon dead, ashy blotches of calla leaves, possibly due to sun scald, a *Pestalozzia Richardiæ*, Hals., is sometimes to be found, almost covering the surface with minute black specks, the spore masses of the fungus.

The Anthracnose of the Rose.

Under the title of "Fungous Diseases of Roses," in the last report, pages 280–283, several species destructive to roses were considered, among which mention was made of an anthracnose. Since then further information has been obtained upon this serious rose enemy, and is embodied in the present paper. The chief feature of this disease is the scarcity of leaves, as shown in Figure 55. Instead of a plant with foliage upon all the canes, there are but few leaves upon some of the stems, while others are entirely defoliated. The whole plant is infested with the fungus, and this parasite so saps the vitality and interferes with the processes of growth that the leaves, even if

they were healthy in themselves, are unable to perform their work. The fact is, that the leaves are infested with the anthracnose filaments, and soon after falling, if not before, they will show the spore forma-

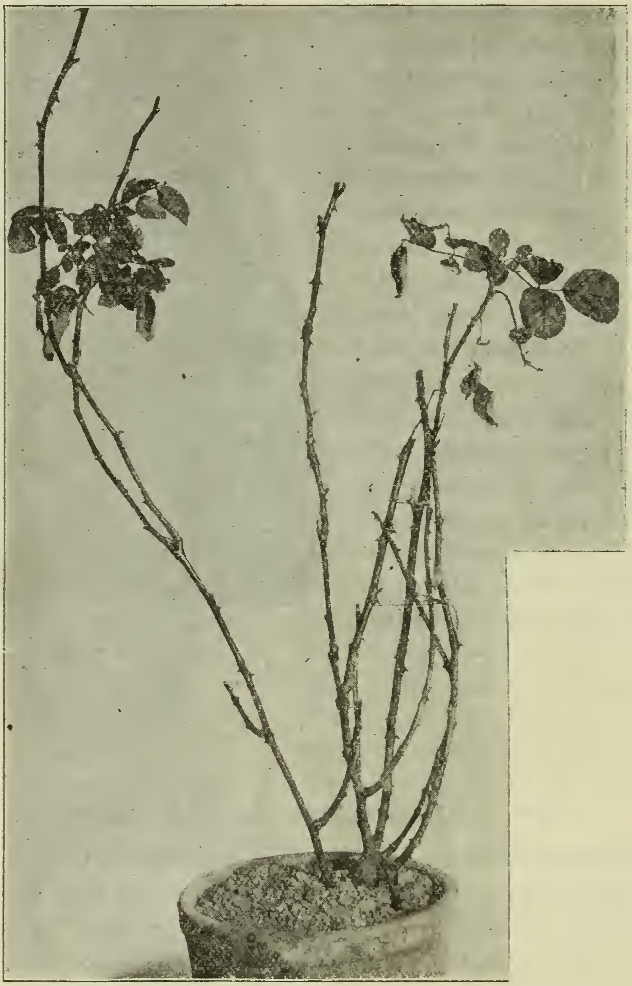

Fig. 55.

Rose affected with anthracnose.

tion of the anthracnose fungus, *Glœosporium Rosœ,* Hals. In general appearance and habits of growth, this fungus is quite similar to the one causing the anthracnose of the raspberry named, *Glœosporium*

venetum, and it is possible it is identical, the presence of the one being, possibly, a menace to the host of the other.

The rose plant is most likely attacked while young, or at least it is

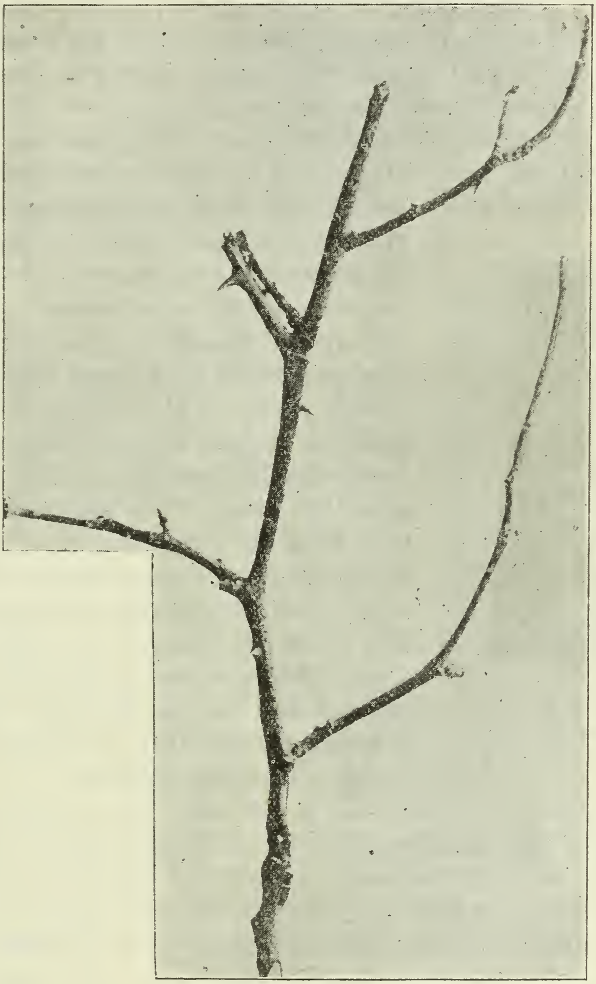

Fig. 56.

Diseased cane, natural size.

to be presumed that the young portions of a plant are most susceptible. The attack is from without, and the spores falling upon the surface of the young, tender canes, and leaves as well, there germinate

and produce, in a short time, an affected spot. If this takes place in a cane, it is natural to suppose that the portion above the infested part will be girdled, in so far as the attack is great, and this will interfere with the direct support by the whole plant of the part beyond the diseased place. Besides this, the fungus spreads, and the more rapidly, in the direction toward the tip of the cane. It is not unusual for a diseased plant to send up apparently healthy shoots from near the base of the stem, these in turn to become infested.

Figure 56 shows a diseased cane, natural size, one taken from a living plant, but without leaves. A careful examination of the cane will show that a point near the middle of the engraving is covered with small pimples. This is the place where the spores of the anthracnose have been formed in great numbers. An enlarged view of a similarly-affected cane is shown in Figure 57. The spore masses are so much enlarged as to be readily seen. This is a piece of the cane, shown in Figure 56, and made a subject for a micro-photograph, but only magnified about five times. Each one of the projections from the surface consists of a mass of spores, and these when moistened flow away, while a multitude of others escape from the rift in the epidermis of the cane. These spores germinate with great ease, and from this fact and the vast numbers formed, it is easy to conclude that the rose anthracnose is a very contagious disease.

Fig. 57.
Enlarged view of diseased cane.

Roses that have a sickly color to the foliage, with the leaves falling prematurely, especially from the tips of the canes, may be suspected as victims of the anthracnose. A hand-lens should be sufficient to assist in finding pinkish blotches upon the leaves, particularly those that lie upon the moist earth beneath the half-defoliated plant. Similar, but better-defined, pimples usually occur upon some portion of the cane.

It will be gathered from these engravings and remarks that the rose anthracnose is a specific disease, caused by a well-defined fungus that grows rapidly from spores, penetrates the substance of stem and leaf and finally causes defoliation and death of the cane. The anthrac-

nose, because of its multitudes of spores produced in pimples on leaves, particularly fallen ones, and the canes, the ease with which they are transported by water and the rapidity of germination, all combine to make this fungus enemy of the roses very contagious.

This class of fungi to which the Glœosporium belongs is amenable to treatment by fungicides. A coating of Bordeaux mixture or ammoniacal carbonate of copper upon the leaves and stems prevents in large degree the entrance of the germs. Therefore all rose-houses where there is any anthracnose should be sprayed with one of the above compounds. It goes without further saying that all plants that are as shown in Figure 55 should be either cut down close to the soil or thrown bodily into the burn-heap.

A Blight of the Variegated Ivy.

This is not the first time (report 1892, pages 294 to 303) that the writer has had something to say concerning the weakness of variegated plants. The white portion of a leaf is less able to ward off fungous enemies than the green parts, and this fact is no better illustrated than in the variegated sorts of the English ivy (*Hedera helix*). Some years ago, while making a special study of variegated plants, this fact was brought to notice, but recently a more emphatic illustration came under observation. From average samples of these blighted leaves, of which there were several hundred, Figure 58 has been made. In order to bring out the prevailing light color of the leaf, the subjects were placed upon black velvet, thus giving them a dark background in the picture.

The form of variegation which prevails in the ivy consists of a blanched area around an irregular central green portion. In some of the leaves this etiolated border extends nearly to the center, when the leaf is nearly white. In others the green central portion reaches to the margin.

The blight, in like manner, is quite uniform in its location, for it almost always begins midway of one side, that is, about half way between the base and apex, and working its way in, does not stop at the line of the green area, but, sweeping across, blackens the whole leaf. Very often the blight begins at the same time upon both sides of the leaf, and the ruin is quickly effected.

Ivy of the ordinary sort growing near to and under the same circumstances as the variegated specimens is rarely troubled, but, however, is not entirely exempt.

The blight, that is, the turning brown and dying of the white tissue of the leaf, is due to the inroads of a fungus of the anthracnose type (*Vermicularia trichella*, Fr.) It abounds in spores, which are the means of the rapid spread of the blight. These spores, when they

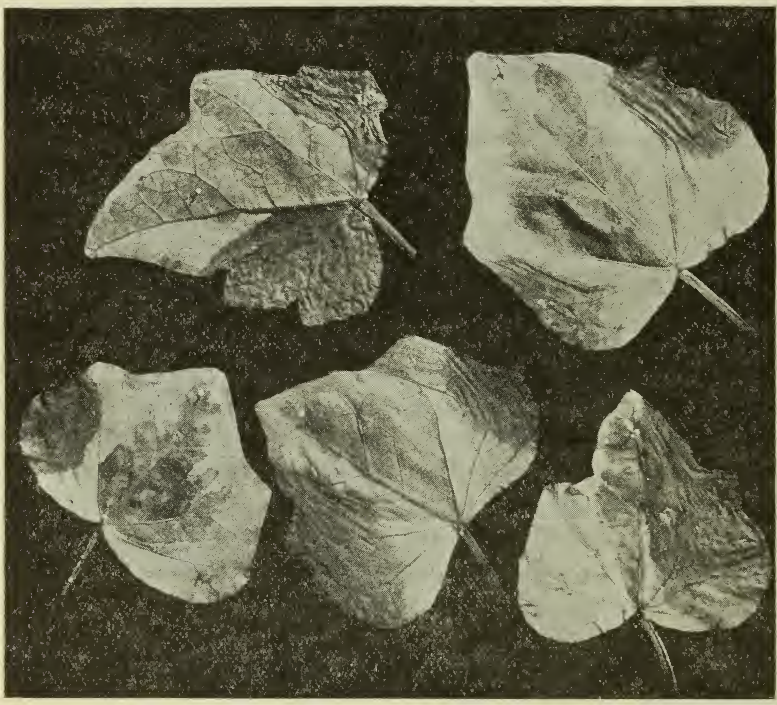

Fig. 58.

Blight of variegated ivy.

fall upon the etiolated portion of the leaf, probably are better able to effect an entrance there than upon the green parts. When once within, the threads grow rapidly and penetrate all portions irrespective of the coloration. After a short time the fungus develops small spots upon the surface like microscopic tufts of black hairs, among which the spores are borne. Each blighted leaf in that way becomes a place where the disease germs are produced in vast numbers.

There are two leading practical points in this connection. Let it

be remembered that the variegated sorts of foliage are much more subject to blights than green ones of the same kind, and therefore if any one prefers the variegated to the ordinary sort, he must lend some assistance to his weakened pet. He can help by removing the blighted foliage as it appears or he may spray the vines with a fungicide. Those who indulge in variegated foliage plants must needs take more than ordinary precautions or else the blights will render unsightly what otherwise may be exceedingly attractive and beautiful.

Palm Diseases.

From time to time specimens of blighted palms have been sent to the Station for inspection, and as the kentias have been the leading ones investigated, this paper will be devoted to the disease which seems to be common to the various species.

Ordinarily the blight appears as shown in Figure 59, where the tip of the leaf for a few inches has become dead and brown. However, the trouble is not confined to the tip, but may appear almost anywhere upon the leaf. Figure 60 shows a portion of a leaf which, while healthy at the tip, has large spots that have been destroyed by the fungus. If the dying was confined to the tip of the leaf it might be concluded that it was, at least in part, due to the extreme susceptibility of the end to untoward influences, whether of fungous or other origin.

Fig. 59.
Tip blight of palm.

Associated with these dead tips and blotches is a fungus of a character to account for all the mischief done. It is one of the anthracnoses and a member of the genus Colletotrichum. Soon after the attack is made by the spores a spot somewhat darker than the ordinary healthy leaf is manifest. The appearance is more nearly described as watery, but quickly the portion becomes dry and pimples appear upon the surface. These somewhat purplish pimples are the spore-bearing points, and from them ooze a

vast number of oblong spores. Here and there in each spore spot are dark, stiff hairs, and under the microscope there is a peculiar view of these bristles and the spores seen upon the surface of the affected area. Further on in the development of the disease the dead tissue falls away and the holes with the strong veins running across them remain.

The anthracnose attacks the seedlings and so weakens them that they are not able to unfold their young leaves. Figure 61 shows two of such seedlings about half natural size. In one a small leaf has unfolded, but the larger one is so diseased at the base of the blade at the point where the pin head may be seen that it was scarcely able to maintain an upright position; in other words, it had become decayed by the anthracnose. In like manner the middle of the unopened leaf is seen by its contracted size to be destroyed and could never spread out. The other seedling shows a similar behavior of the parasite, the blight in the middle of the larger unopened leaf showing plainly by its contracted appearance.

One is not able to decide at what time the disease first started in these seedlings. It is most likely that the spores found their way to the young leaf long before it appeared as such, and what with the warmth and moisture of the palm-house and the tender tissue of the young leaf they were able to develop sufficiently to ruin the seedlings.

With older plants, the spores falling upon the leaves and kept moist are soon able to send their threads within the host and inaugurate an initial point of decay. The spores of all these forms of anthracnose germinate rapidly wherever conditions are favorable, and there is no mystery connected with the rate of development of the disease.

Fig. 60.
Palm leaf spot.

As remedial measures there are two suggestions to make. In the first place all

blighted parts should be removed. It is not unusual to find in palm-houses some of the older leaves which are dead down to their insertion with the stem. They may have fallen away and lie upon the bench. Such leaves and leaf stalks are usually covered with the spore spots, and contain millions of spores. Such refuse, worse than worthless, should be removed and burned. In cutting off the tips of the leaves that are blighted too frequently, the knife passes too near the dead part, and soon after the anthracnose appears upon the stump of the leaflet. The suggestion is to cut lower down, and usually it will be better to remove the whole leaf.

Fig. 61.
Seedling disease of palm.

As a second means of checking the palm blight, a spray of Bordeaux mixture or carbonate of copper compound, once each week, will doubtless prevent many spores from gaining a foothold in the healthy foliage upon which they may have been carried by the water or otherwise.

The following kentias have been found victims to the same anthracnose, namely, *Kentia Belmoreana* and *K. Canterburyana*, both old leaves and seedlings, the ones shown in Figure 61 being of the first-named species. *Kentia Fosteriana* shows the same in leaves of old plants; but also before they unfold. The fungus may well bear the name of the genus, and is called *Colletotrichum Kentiœ*, Hals.

Leaf Blight of Caryotas.

The caryotas are among the most attractive of our palms grown for indoor decoration, and it was with many regrets that recently the writer saw a score or more of young plants with their leaves badly blighted. The accompanying engraving will give the reader an idea of the general appearance of the pair of leaflets that are badly affected. Near the center of each is a large, long, ashy spot, shown natural size in the engraving, Figure 62. This light area is surrounded by a

Fig. 62.
Caryota leaf blight.

brown, almost chestnut border, while over the central portion are many small specks, seen with ease only with the hand-lens. These are spore spots and consist of rifts in the skin of the leaf through which the fungus protrudes, and bears its multitudes of spores.

It would be interesting to study the development of these blighted patches, and determine whether some injury is needed to so weaken the tissue as to permit the fungus to get a foothold. However this may be, it seems true that when once within, it is able to grow, extend through and finally ruin the leaf.

One of the surprising features of this blight is the quite uniform location of the single spot near the center of the leaf.

As for a remedy, there is perhaps nothing better than the cutting away of these blighted leaves and burning them. A leaf that has its center killed as has the one shown in the engraving, can only become worse as time goes on.

Fig. 63.
Young dracæna blighted.

The fungus found associated with these spots, whether the cause or secondary to some injury, as sun-scald or the like, is a species of anthracnose, and if it is the cause, it would doubtless be amenable to treatment like a similar fungus upon the kentias.

Blights of Dracænas.

Dracænas and the closely-related cordylines, often classed together under the common name of Dragon Trees, furnish a large group of highly-prized hot-house plants. Within the past few years some of the cultural varieties, and particularly those of *Cordyline terminalis*, noted for the beauty of their dark-green, bronzy and crimson foliage, have failed to preserve their health, becoming badly blighted and thereby worthless. In several of the larger dracæna-growing establishments of the Eastern States recently visited the majority of these plants presented a sickly appearance, while some gardeners are giving up growing them at all.

The disease is not confined to any one stage in the life of the dracæna plant, for the blight may be found upon those that are small as well as those of larger size. Figure 63 represents the blighted appearance of a young plant, photographed and engraved, one-half natural size.

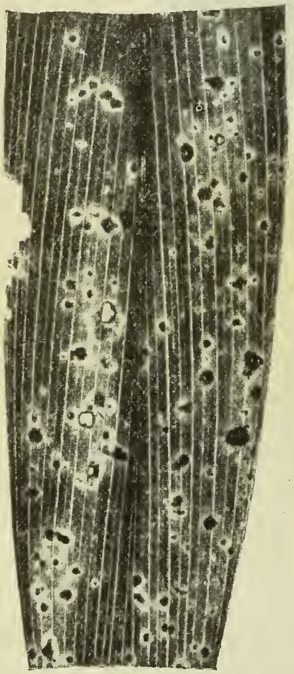

Fig. 64.
Portion of dracæna leaf.

The fungus which is to be credited with this destruction of the dracænas is *Phyllosticta maculicola*, Hals., and may be recognized by its producing small brown, somewhat angular spots in the leaves, with a surrounding of yellowish color. These brown spots finally contain the minute spore-bearing pimples from which the spores ooze out in a long, colorless coil. By means of these spores the disease is enabled to spread with considerable rapidity. Figure 64 shows a portion of diseased leaf, natural size.

Some of the other species of dracænas are similarly affected; but a leaf blight that is most destructive to the thicker-leaved sorts, as *Dracæna Goldieana*, particularly the variegated *D. Lindeni*, is *Vermicularia Concentrica*, Lev., which produces large brown blotches in the leaves.

Leaf-Tip Blight of Dracæna Fragrans.

From time to time bits of leaves of *Dracœna fragrans* have been sent to the Experiment Station with a complaint that the plants are not doing well, and in commercial green-houses they become unsalable. The trouble in question is another one of those caused by a fungus, or at least it is the active agent of destruction when the leaves reach me. The foliage of the plant is of a texture and thickness that render it a favorable feeding-ground for fungi, for they as a rule love succulent plants, all other things remaining constant. It is often the tips of the leaves that are most subject to the bad effects of the blight, and this is true of many other than the dracæna plants. This may be due to the fact that the water holds to the pendent tips longer than to any other portions. When the plants are sprinkled the upper portions of the foliage retaining only a film of the liquid quickly dry off, while the water descending to the tips remains there for a long time. The presence of this moisture upon the surface of the leaf-tips furnishes the proper conditions for the germination of spores that may have been brought there by the descending water as it flowed along, gathering to itself the spores previously deposited upon the surface of the leaf. It is thus seen that there are at least two good reasons why the tips of drooping leaves may be infested with fungi while the upright parts escape. As a matter of fact, however, such portions do not escape. Not infrequently in the case in hand the dracæna leaves may be blighted midway of the tips and base. In such instances it is possible that sometimes there has been some injury by means of which the spores found an easy place to germinate, and their germ tubes to penetrate the leaf.

There is a third reason why the tips are more susceptible, namely, the greater surface exposed to the amount of tissue than in the other parts of the leaf. The entrance of disease germs is largely a surface action, and therefore the chances are greater as the tip of the leaf is approached. The tips being thinner and farther from the base of interior water-supplies, often suffer from wilting, and become dried naturally. Anything of this nature assists the parasites to get a foothold. The wonder is that more tips are not attacked. When once a fungus has established itself, it will begin to work its way in the leaf toward its base. This advance may be quite uniform and rapid, so

much so that there is a distinct line between the living and the destroyed tissue.

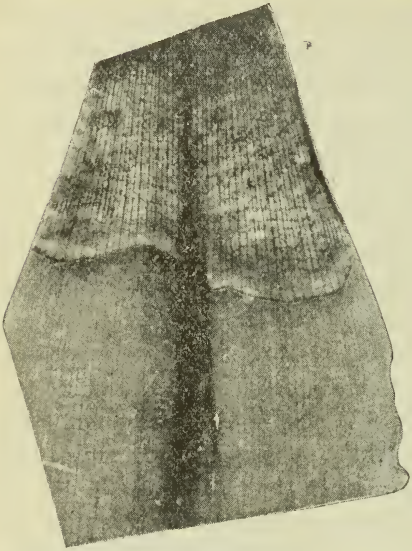

Fig. 65.
Tip blight of dracæna.

The accompanying engraving (Figure 65) shows a portion of a leaf of *Dracœna fragrans,* and illustrates the point above stated. The dead tip was cut away before the photograph was taken. This tip had taken on a straw color, while the healthy portion in the lower half of the engraving was of a pale green. The line between the healthy and diseased tissue is very marked, due to the rapid shrinkage and paling of the latter.

The fungus which was destroying the leaf inch by inch is a species of anthracnose of the genus Glœosporium, and doubtless could be prevented from getting a foothold in the dracæna foliage by weekly sprayings with any standard fungicide.

A Sobralia Blight.

There are several fungous enemies that prey upon the orchids. Sometimes the pseudo bulbs are attacked and quite large pits are produced in them. Again, the foliage suffers greatly, as in the bletias, and still more general and damaging is a spotting of the blossoms.

The particular trouble to be mentioned here is the one of the sobralia. Not long ago, during a run through a commercial greenhouse, a number of plants of *Sobralia macrantha* were found, the foliage of which was practically ruined. Specimens when afterward subjected to microscopic examination showed a clear case of the destruction by a fungus.

The blight is due to the inroads made upon the leaf by an anthrac-

nose of the genus Glœosporium (*G. cinctum*, B. & C.) This is another case of the fungus most frequently flourishing at or near the free end of the leaf and spreading from there toward the base. Figure 66 shows a badly-diseased leaf in its middle portion, the upper half or more being ruined by the fungus, and the lower portion comparatively healthy, while the line of advance of the disease is well defined.

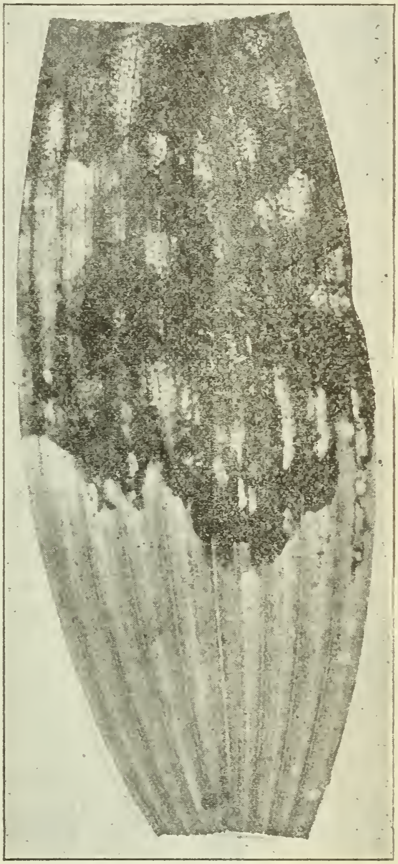

Fig. 66.
Sobralia blight.

When a sobralia plant bears leaves like the one shown, it is evident that no amount of spraying will effect a cure. The spores are being produced in great numbers and carried off with every drop of water that drips from the foliage after watering. In other words, such leaves are propagating the disease in a wholesale manner, and there are various ways for the germs to find lodgment upon neighboring healthy plants.

Spraying with Bordeaux mixture or other fungicides will assist in preventing the spores from germinating upon healthy plants, but in addition to the spraying, the source of infection should be removed. When a plant is badly affected with an anthracnose the fungus is usually spread all through it and not simply in the leaves, and there are many chances against ever saving the plant even by severe pruning. In many cases it would be folly to attempt to propagate from such plants with the hope of getting healthy specimens.

A Leaf Spot of Bletia.

The large, thin leaves of the handsome orchid genus Bletia are subject to a spotting that much disfigures them and materially decreases their usefulness. These spots are at first almost black, and, the soft

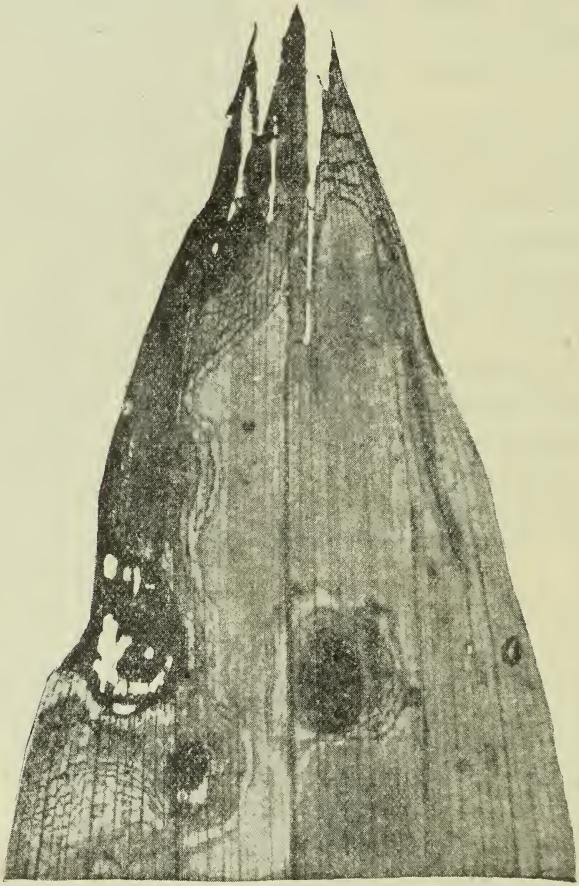

Fig. 67.
Bletia volutella blight.

parts of the leaf soon breaking up, only the fibrous portion remains as ribs across the open spaces. The tip of the leaf is quite sure to be attacked, and presents a broad, ragged end of dead tissue.

This spotting of the bletia foliage is due to one or the other, or both, of two fungi, both quite different in their appearance, under the microscope, but producing nearly the same effect in the leaf. The first one is an anthracnose of the genus Colletotrichum, and grows rapidly in the soft substance of the leaf. This fungus causes large dark-brown blotches, which turn sometimes to a gray in the center. Over the diseased area small spore masses may be seen with the hand-lens. These are light brown in color, and have numerous hairs of the same or a darker color. This is the *Colletotrichum Bletiæ,* Hals., and can doubtless be controlled by fungicides, which should be used by those who would have their orchids clean from this pest.

The second fungus associated with the spotted and shredded bletia foliage is a species of Volutella. The large dark spots, when viewed with the hand-lens, are seen to be studded with numerous balls of a lemon color. The most peculiar feature is the concentric rings of bluish color that surround each brown spot.

Figure 67 shows a bletia leaf that is infested with the Volutella, and the rings are dimly visible. On account of these concentric rings the fungus has received the name *Volutella concentrica,* Hals.

While it is possible that a bacterial disease or the anthracnose may precede the Volutella, this fungus is quite constantly present, and is held responsible for the trouble provisionally. Treatment as recommended for the anthracnose should eradicate it, that is, keep healthy leaves from becoming spotted, by the use of a fungicide. Old diseased foliage should be destroyed so far as it can be spared by the plant.

The Petal Blight of Orchids.

Of late there has been more complaint made of the spotting and other forms of decay of the petals of orchids than heretofore. Whether this is due to an increase of the trouble or not it is impossible to say, but the fact remains that many of the orchid-houses in New Jersey and elsewhere show a large percentage of the petals of

the incomparably rich blossoms more or less disfigured. (See Figure 68.)

This blotching is due to one or more of many causes. It is to be remembered that the tissue of the floral part is exceedingly delicate in structure, and also the colors are such that any disease is remarkably conspicuous. Sometimes the spotting consists of minute specks, in great numbers, scattered over the whole surface of the petal, and so uniform is this that one might almost conclude at first sight that it was characteristic of that particular species of flower. It is often true that the little specks will be bordered by a delicate ring of pink which will heighten the peculiar appearance of the blighted portion.

Fig. 68.
Orchid-flower spots.

Attention is here called in particular to a blight that causes large areas of the petal to become disorganized. It may be that there is only a single blighted patch, and this, by rapid increase, spreads throughout the whole floral orchid, or as is shown in the accompanying engraving, there may be two of these diseased places. When a petal is thus attacked it soon becomes worthless and falls down, either remaining attached by its base or drops away entirely. Such patches upon examination with the compound microscope reveal the presence of a fungous growth which is well known to the gardener as the gray mould. This gray mould (*Botrytis vulgaris*) is the most common to be met with upon old blooms in green-houses or other warm, moist places, and abounding in spores which are borne upon the tips of slender threads, it keeps

the atmosphere well stocked with germs, and these falling upon the delicate tissue of the orchid bloom will induce decay similar to that shown in Figure 69.

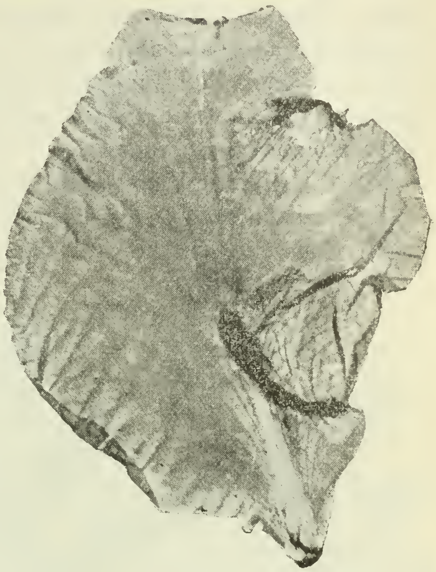

Fig. 69.
Orchid-flower blight.

As a precautionary measure it goes without further saying that any and all old and worthless parts of green-house plants that are harboring this gray mould, or in fact any fungous growth, should be promptly removed from the plants and consigned to the furnace. In this way a large portion of the decay of petals and other floral parts will be obviated.

Botrytis is able to gain a foothold within the vigorous leaves, particularly when some petal or other floral region already infested with the gray mould falls upon the leaf and remains there. The fungus therein spreads from the petal to the leaf and shortly a blotch is formed upon the leaf, which continues to spread for some time, and possibly the decaying leaf in falling upon another will continue to spread the disease.

Tip Blight of Ornamental Ferns.

It is no new thing for those who grow ferns under glass, and this includes all who have one or more in the bay-window, to complain that their pets become brown at the tips and thereby lose much of their green freshness or fresh greenness. There may be many causes for this unsightly appearance.

In the first place let it be understood that the tips of plants are the most tender portions. It is there that new growth takes place, and on that account the cell walls are thin and easily influenced by

outward circumstances. These unfavorable surroundings may be an insufficient water-supply at the roots, when the tip of the fern plant will wilt, and if the neglect is prolonged the young part dries out and dies. It may be that some poisonous gas finds its way into the air surrounding the room and thereby the plant is injured. Extremes of heat and cold in like manner may be the means of checking the vital action at the most susceptible point and as a result the tips of the delicate fern become brown.

There is still another reason for this injury so often met with, and because none of the above deleterious conditions obtain it is all the more mysterious and difficult to remedy. The germs of low forms

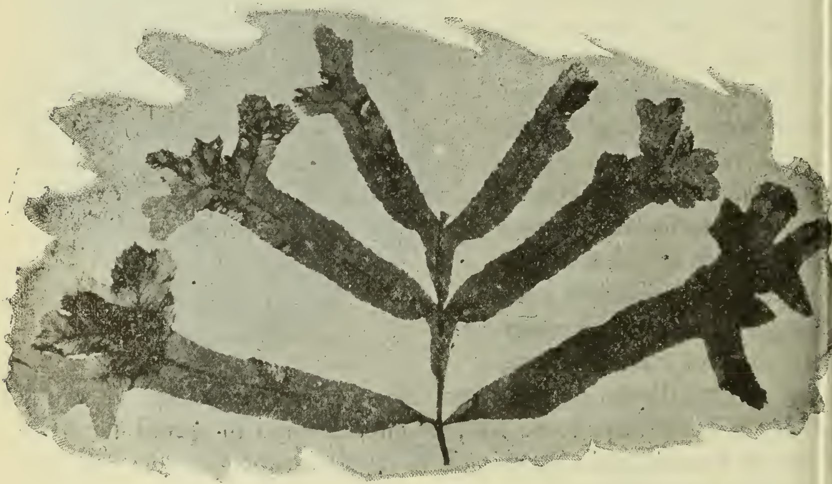

Fig. 70.
Fern blight.

of life are probably present in the atmosphere at all times, but being microscopic they pass unheeded, and only their effects are noticed. The various forms of contagious diseases of man, as the cholera, yellow fever, consumption and a long list of maladies of domestic animals, are due to these germs, which, multiplying with great rapidity in the victim, cause death. Plants are not exempt from these or similar germs, and show their susceptibility in the various forms of rots, blights, etc., that are constantly met with.

Our ornamental ferns do not escape, and the dying of the tips is frequently a case of destruction due to the growth in the fern frond of

an organism that, acting as a parasite, feeds upon the vital fluids at the centers of life and causes them to turn brown and die.

Figure 70 is made from a sun-print of a portion of a frond of one of the most ornamental of our ferns, namely, *Pteris cretica*, var. *magnifica*. This particular spray was chosen for the picture because it illustrated the dead patches as often being below the tip. As a rule, the blight is confined more closely to the tips than in this specimen, and serves a double purpose, namely, to show the injured extremities and how the same fungus may make its attack elsewhere and produce the same results in the older and stronger tissues of the fern frond.

We are now ready to glance at the nature of this microscopic destroyer. It starts as a minute body, the spores of which, coming from some blighted spot, begin to grow by sending a slender thread into the fern. The spore may be carried by the wind, or perhaps more frequently, by the water that flows from a diseased place to a healthy one, in the process of watering. No change is seen in the fern for a few days after germination, but all this time the fine threads from the spore have been growing in the substance of the frond. The first thing to be observed in the history of a blight like this one is a loss of the green color in the frond, soon followed by the appearance of the ashy-gray spot surrounded by a border that is either purple or brown. So soon as the light disfiguring spot appears, minute pimples form in the blighted area, and these bear the multitudes of spores common to this genus (Phyllosticta) of leaf blights. By means of these spores the fungus is able to spread rapidly.

The blighted leaves of the fern are in themselves unsightly and may well be removed. To protect the healthy foliage it may be sprayed with Bordeaux mixture or other standard fungicide. The spraying of healthy plants may prevent the spores already upon the surface from germinating, and a like treatment of spotted plants may kill the spores as they are forming.

It is thus seen that while the fungous enemies are the most obscure, they admit of being known when studied with the compound microscope, and of successful treatment to prevent them, if the spraying is done thoroughly and promptly when the plants show signs of spotting. There are fungous diseases that when far enough along to show their presence are too far advanced for the application of a remedy, the whole plant being sick at heart. But this blight (*Phyllosticta Pteridis*, Hals.) of the fern is not one of these.

Bacteria in Some of Their Relations to Crop-Growing.*

From time to time horticulturists, and all other crop-growers, have been admonished to consider well the small things that pertain to their important craft. There may be smaller subjects demanding our attention than bacteria, but they would certainly be difficult to find, for these microbes require the higher powers of the compound microscope to become visible. It is, however, true of them as of many other minute things, that what they lack in size is fully balanced by their great numbers. The air and the earth and the waters under the earth, it might almost be said, abound in bacteria. They are known to man, as a rule, only by their effects, and while we may briefly consider their form and structure, it is only as a preparation for the consideration of some of the relations which they bear in their activities to the growing of crops.

Bacteria are microscopic organisms belonging to the lowest of all known groups of plants, and therefore they come within the province of the botanist. But the study of these minute forms of life is of such a special nature that the separate name of bacteriology is given to the particular branch of botany to which these microbes belong, and the worker in the group with all his bacteriological apparatus is styled a bacteriologist.

While it has been but a few years, comparatively, since these plants were known, the growth of the science of bacteriology has been wonderfully rapid. Investigations until very recently have been chiefly with those forms that prey upon man and the higher animals, and produce as a result very many of the most dreaded contagious diseases. The fact of the contagious nature of human and other bacterial maladies is explained when it is demonstrated by inoculations and otherwise that microscopic germs pass from the sick to the healthy subject through the medium of the air, drinking-water, food, clothing, and a score of other ways. While the above is being written the daily paper comes to hand containing the account of a fatal outbreak of diphtheria in a house built on low land upon a garbage pile, through which a well had been dug. It is most likely that the water contained the germs of death, which were brought there in the refuse possibly months or years before.

* Presented before the New Jersey Horticultural Society, at its last meeting.

On every hand the progressive physician guards his patient against the inroads of these bacterial germs, and the healing art to-day is largely a fight with an unseen enemy with well-tested germicides, whether it be the dreaded fevers that if left uncontrolled, sweep the heated, filthy city with a besom of death or these low forms of stealthy foes which by degrees, as in consumption, supplant the healthy tissue with corruption.

Bacteria, through the havoc they make in the individual, the family and the community, are now recognized as active agents that may be expected in some of their forms at any time. That they are the creatures of filth and most abound where the rules of good sanitation are unobserved, is also becoming known. In short, we will recognize that bacteriology as applied to human medicine merits even more than the large share of attention it is now receiving in the medical schools, and the daily practice of the family physician.

That plants are subject to attacks from bacteria is not so generally understood, and the relation they sustain to crop-growing is perhaps more intimate than any one is willing to admit to-day.

From what was said above in regard to the contagious diseases being caused by bacteria it might be gathered that these germs were always our foes. Far from it, for as was stated they are the children of filth and thereby become scavengers in the highest and best sense.

These minute germs, so small that twenty-five thousand placed end to end may not extend an inch, and multiplying with a rapidity that is most astonishing, are the means of preserving life upon the earth. It is by their activity that organic substances are quickly decomposed and brought into available condition for higher plants. The great majority of bacteria are our friends, and it is only when they trespass upon the domain of life and become parasitic that their greatest mischief is done.

Aids to Crop-Growing.

In many ways bacteria aid more than in the preparation of the food elements. It is by means of these germs in large degree that the fertilizing materials applied to the soil are loosened in their close combinations and set free in a form acceptable to the growing plant. Elaborate experiments in the field by Messrs. Lawes and Gilbert at Rothamstead, England, and elsewhere, show very clearly the value of

the presence of soil microbes, and it is likely that the day is not distant when the germ of nitrification will be cultivated and applied to the soil.

There are two kingdoms of life upon the earth; the one we call animal and the other vegetable. The ordinary vegetation of the field, for example, the plants that form our crops, obtain their food from the soil and the air, while animals live almost entirely upon the products of vegetation. Plants construct their substance out of the inorganic compounds, as water, carbonic acid and various salts of potash, phosphoric acid, lime, magnesia, etc., obtained from the soil. They also require a certain percentage of nitrogenous substance, and this is furnished ordinarily by the decomposition of complex compounds containing nitrogen. In order, therefore, that there may be a constant supply of food for the animal world, there needs to be a corresponding production of plant-food by the processes of decay. The bacteria are the leading agents in this work, and they stand between the animal upon the one side, which require plants to prepare their food compounds, and the vegetable world upon the other, which cannot feed directly upon the tissues of either animals or other plants, but thrive when these same tissues are decomposed through the action of decay. A corn plant, for example, cannot grow upon albumen as beefsteak, or eggs, or upon starch, or sugar, or a combination of these three sorts of substances. But when they have undergone putrefaction or fermentation they become available as food for the corn plant. It is the prime function of bacteria and yeasts, which are similar low organisms, to tear down the complex molecules and leave in their stead the simpler ones of carbonic acid, ammonia or some other compound of nitrogen which the crop plant will greedily relish. Bacteria, when free to act, quickly convert the highly-organized and unstable substances into stable and simpler ones, thus permitting the same material to be used over and over again, and preventing an undue accumulation of vegetable or animal products that in the end would bring stagnation and death.

When we think of bacteria as the cause of so much suffering to the human family in fevers and scores of other contagious diseases, one is inclined to raise his hand against them all. But viewed from a wider field of vision and seen in the light of many facts, it becomes evident that there could have been no hand to raise under the present plan of creation without these creatures to render human life possible upon

the earth. "Despise not the days of small things" is a statement brim full of wholesome admonition and suggestion.

Nature looks at these bacteria, even when they are feeding upon our kindred, in a far different manner from ourselves. Here is the germ of scarlet fever, for example. It is a beautiful but simple microscopic sac, and makes new sacs when well conditioned with wondrous rapidity. It thrives in the tissues of the sick girl as does the wheat in the rich soil or the pigs in the clover. We will not consider the enjoyment the colony of bacteria found in each other's intimate society within the burning cheek of the child. Nature says to herself, these are active germs; let some of them escape, and the winds may carry them to the neighbors. In some way they gain a foothold at the Robinsons' or the Johnsons' and have their run, and move on or perish, as the case may be. They are a part of the great scheme of creation and have their purpose to fulfill. To live is to contend against the life that is striving to succeed by overcoming us, whether it be in the form of an enraged bull or the insidious bacteria. There is a line of battle even in "the piping times of peace." And this brings us to the more warlike side of our subject, namely—

Bacteria as Destructive to Life.

When microbes are busy decomposing the refuse of animal and vegetable life, we contemplate them with the same degree of complacency as the garbage-gatherer returning the empty barrels from his passing cart. But when they in mighty power boldly attack that which we hold most dear, the scene changes and they then are on a footing with the garbage man should he take away the filled barrel in one hand and a beloved child in the other. The loss is heavy and grievous to be borne. Some action must be taken; the sewer looked after and the enemy met and vanquished.

In a similar manner the crops of the field, orchard and garden may suffer from the inroads of bacteria and it is our purpose to consider some of these.

They are called bacterial diseases of plants and not the least of the obstacles to profitable crop-growing are these microbes.

The honor of having been the first to discover the bacterial origin of a serious malady of plants belongs to an American botanist, Dr. Burrell, of the Illinois University, who demonstrated in 1878—note

the recent date—that the twig or fire blight of pears was due to the invasion of a specific microbe. It is not the purpose here to review the steps by which this remarkable conclusion was obtained or the many other investigations upon the same malady which confirmed the results. This was the beginning of a branch of study which has yielded rich returns in facts and is quite soon to throw a flood of light upon many of the obscure maladies of our crop plants. It is our purpose to mention in brief outline a few of the other plant diseases that are now generally conceded to be of bacterial origin.

The sorghum blight is one that affects the leaves, particularly the sheaths, producing crimson-red patches and a destruction of the cell contents. Dr. Burrell, the discoverer of this microbe, named it *Bacillus Sorghi*, and later the study of it was continued at the Kansas Experiment Station by Professor Kellerman. There is a corn blight related to the sorghum germ in appearance and pathological changes produced in the tissues. This is the *Bacillus Zeæ*, of Burrell, who issued a bulletin upon the subject under the title "A Bacterial Disease of Corn," in August, 1889.

In Europe one of the first diseases of plants due to microbes that was studied is the yellows of the hyacinth. This, Wakker in 1883 found was the result of a specific germ (*Bacillus Hyacinthi*, Wak.) which thrived in the bulbs and leaves, causing a degeneration of the tissue and a gummy exudation of a yellowish color.

In 1887, Savastano published an account of his studies of a germ disease (*Bacterium oleo tuberculoses*, Sav.) of the olive, which since has been found to be present in the grape, fig, orange and several other trees, and is one of the leading enemies to fruit-growing in California.

Within the past three years, that is, all within the '90's, there have been several leading diseases of crops ascribed to the prevalence of bacteria. Thus, in 1890, Professor Galloway found a blight of young oat plants due to *Bacillus Avenæ*, Gal. The same year Dr. Arthur in his study of carnation diseases, found a peculiar blight due to a germ (*Micrococcus*), and Professor Bolley determined a bacillus to be associated with a form of scab in the Irish potato. One of the soft rots of the potato, emitting an offensive odor, was found by Dr. Burrell and others to be due to bacteria. This the writer found abundant in some of the counties in this State, and in an investigation in Mississippi, it was found to be common to the tomato, and plants like

the squash and melon. This disease is quick-acting, and healthy tissues, when inoculated, soften and decay in a few hours. A similar rot of vegetables is not uncommon among stored carrots, turnips, salsify and onions. There is a germ that works upon the leaves of celery while in the field, the affected portions becoming brown and watery, and when banked the whole plant may decay from the heart outward.

It will be seen from this incomplete enumeration that there is a long list of serious plant diseases that have already been traced to bacteria, and doubtless many others, now very obscure, will be similarly disposed of.

Method of Attack.

Dr. Russell, in his recent paper,* founded upon a prolonged study of the subject, concludes that the "healthy plant, with intact outer membranes, is free from bacteria within its tissues." Much stress may be laid upon the word *intact*, for there is no question but that the germs readily found entrance where the interior tissue of a plant for any reason became exposed. It therefore follows that one of the leading precautions connected with the checking of bacterial diseases in plants is to preserve the skin of all parts of plants, whether of stem (bark) or leaf (epidermis) from injury. There is a strong probability that many micro-organisms may get a foothold through wounds that could not effect a direct entrance through the natural barriers of the skin, and, on the other hand, it is likely that those germs which are strictly parasitic find their way into the plant where its surface is wholly intact. But in this connection it needs to be said that there are organs of a plant which particularly favor the entrance of germs. Thus the pear blight infection can be induced by spraying the flower clusters with the decoction of germs. It is possible that the exudations of such parts in the form of nectar may permit the baeteria to multiply upon the surface until a ferment is produced capable of softening or even decomposing the tissue of the more tender parts. As a rule, so far as experiments have gone, it is the young parts, as the blossoms above stated, or the tender opening buds, particularly of seedlings, that provide the entrance of the disease germs. In many instances, doubtless, the point of attack is below ground, and there the most succulent young roots or even the delicate root hairs are penetrated.

* "Bacteria in their Relation to Vegetable Tissue."

It should not be forgotten, however, that in the leaf epidermis there are usually innumerable minute openings, the stomata, and these furnish a direct communication with the interior tissue. Through these passageways the bacteria may enter just as the germ tubes are known to do of numerous kinds of mildew, rusts, moulds and higher sorts of fungous parasites. In fact, in the study of some of the bacterial diseases of leaves, the first points to become affected are found with the stomata in their centers. If the infection is from the soil through the roots, and not directly from the air, the case is different, and the soft parts bordering the framework may first show the blight.

Young stems often provide in the minute openings called lenticels, an abundant opportunity for the entrance of the germs.

After the bacteria are once within the plant, and we see there are many ways of entrance, the hardest point in the conflict is overcome, and the spread of the disease will naturally follow the younger and more tender tissues offering the least resistance as well as the best feeding-ground.

It is dangerous to draw analogies between plants and animals, and none more so than with matters of circulation of the juices. When any substance is injected into a blood vessel of an animal it is quickly conveyed to all parts of the system. There is no such immediate result obtained by the inoculation of a plant. While all the protoplasm of a whole plant is now thought to be connected by means of minute fibrils passing through microscopic pores at certain places in the cells, and in this way the vital portion of a plant is a unit, there is no outgoing and incoming fluid driven by the muscular contraction of a central pumping engine. Therefore, bacterial diseases are more local in plants than animals, as a rule, and their spread dependent more upon diffusion in its broad sense than circulation. Unlike the juices of animals, the cell sap of plants is not strictly germicidal, but it is nevertheless true that there are secretions that render protection in various ways, as tannin, turpentine and various ethereal oils. Concerning immunity and resistance in plants there is little yet that is known, and probably the leading means of defense are the natural barriers consisting of an outer layer designed for protection of the more delicate parts within, and everything possible should be done to keep it intact. This should be seconded by proper conditions for the growth of the plant, so that it may not be infected by insufficient food

and water-supply, excess of heat or cold, etc. In short, the plant should live up to the high mark of full vigor, that its power to resist inroads of bacterial enemies may be the greatest.

Remedial Measures.

The last subject in this connection is the one of the remedial agents. It has been shown that several of the leading plant diseases are due to micro-organisms. These organisms enter the victim from the soil through the roots or directly from the air by means of the stomata and more particularly the delicate tissues of young leaf and flower buds and other tender growing parts. The germs after they have once effected entrance are not within easy reach of any known fungicide. All attempts to dislodge them by applying chemicals to the soil have thus far proved ineffective. There remains only the use of the knife, and by it removing the diseased parts when the trouble is localized. In case of the pear twig blight it may be possible to remove the bacteria, but care needs to be taken to cut far below the point where apparently healthy tissues join that which is diseased. In the case of a smaller plant, as one like the calla, it is possible to remove the crown, and from one side of the decapitated corm new shoots, when formed, may be free from the disease. The knife, as before mentioned, is effective only when the disease is confined to certain localities, and in such instances the germs probably enter from the air at some vulnerable point and not from the roots.

Remedies in the form of fungicides can doubtlessly be applied in some cases with good results. For example, the potato scab is caused by a micro-organism that is certainly contagious, and can be largely controlled by treating the seed potatoes. One substance that has proven effective is corrosive sublimate, dissolving two ounces in fifteen gallons of water and permitting the potatoes to soak in this for an hour and a half. Excellent results have been obtained by the spraying of the seed and the soil in the open furrow with the Bordeaux mixture.

While it is clearly recognized that potatoes as used for planting are not true seed, there is no reason why it is not possible to so treat the seeds of beans and other plants that the germs of future trouble may be destroyed. Peas, for example, in germination are frequently attacked by bacteria and fail to send any leafy shoot above ground.

It is possible that such seed can be saved from decay by being soaked in a germicidal solution before planting.

With plants that are past the period of germination it is possible to save the crop by the judicious use of fungicides. This has been shown with striking clearness in some field experiments of the potato at the Vermont Station, where the untreated vines died of a bacterial blight and the crop was a failure, while adjoining rows sprayed three times with the Bordeaux mixture gave a large yield of sound tubers.

Similar results are to be expected from the spraying of tomatoes, as the germ is most likely the same, and the host plants are close of kin. With many truck products, including melons, cucumbers and various root-crops, the spraying is more difficult; the young plants are close upon the ground, and the greater moisture induces decay, when the more upright plants might escape. But even here there is hope if the remedies are applied early, frequently and faithfully.

The most difficult bacterial problems are found in the green-house, where heat and moisture prevail, and the plants are tender from their forced growth. But even here the bacterial blight of the carnation, geranium, violet, cyclamen, palm, calla, lettuce and other plants may be checked by spraying, not so much the plants themselves, perhaps, as the soil which harbors the germs.

Bacterial Leaf Blight of the Calceolaria.

The lower leaves of the calceolaria plants that are nearing the time for sending up the flowering stem are frequently blotched with brownish patches. These patches are peculiar in that they are many-sided, being bounded by the smaller veins of the leaf. When a diseased leaf is held up toward the light these diseased portions are much more striking in their appearance and peculiar outline. When first observed, the writer was reminded of similar brown patches which frequently may be met with in coleus leaves and those of the ornamental salvias. These diseased patches in the foliage of the coleus, salvias, etc., are produced by eel-worms, as was explained with a figure in the report of 1891, pages 310 to 313. It was natural at first sight to associate the similar patches in the leaves of the calceolaria with the work of the nematodes, but a prolonged search for these

worms proved fruitless in that respect, and the conclusion that the diseased patches were due to the destructive activities of bacteria was obtained. Germs of a micrococcus were found invariably in these brown areas of the calceolaria leaf and prevalent in the juices obtained from sections made near the base of the leaf. This, rather a broad and fleshy portion of a diseased leaf, was usually of a brownish color, and it does not seem unlikely that the micrococci entered the leaf through the short, fleshy petiole and, finding their way along the

Fig. 71.

Bacterial disease of calceolarias.

channels of the fibro-vascular bundles, spread out here and there in a remarkably irregular manner through the fine tissue of the blade of the leaf. Their further spread through the leaf was, it is likely, checked by the finer veins of the leaf. The characteristic appearance of this bacterial disease of the calceolaria is shown in Figure 71.

The individual germs are practically spherical and above the average size for members of the genus Micrococcus.

Dropsical Pelargoniums.*

For the past two or three years there has been an increased number of complaints made to the Experiment Station of a disease among the hot-house pelargoniums. Specimens received from at least a dozen places all agree in the chief essentials, while there are many variations in the details of appearance to the unassisted vision.

While the trouble is most noticeable upon the leaf blades it is by no means confined there. Upon the stem it shows itself in peculiar corky ridges, which are not infrequent upon the petioles. Upon the blades the usual appearance is that of numerous specks which seem to be supercharged with water, giving to those parts a clear, amber look when held up to the light. The first thought was of bacteria, there being a resemblance of the watery glands to specks found in the carnation leaves previously studied and known to be due to micro-organisms.

After making a full test for bacteria and failing to secure germs or any signs of contagion by inoculation, it was concluded that the pelargoniums were suffering from a dropsical affliction, and instead of the trouble being due to any parasite it seems to be entirely physiological. Photo-impressions were taken of the leaves showing different phases of the disorder.

In a green-house devoted entirely to pelargoniums the trouble may be seen upon nearly all the plants, in which case the middle-aged leaves show the water-soaked appearance to best advantage. Later on, moulds of the black (Macrosporium, sp.) or gray (Botrytis) sorts come in to obscure the view and hasten the destruction of the foliage. The leaves affected with the dropsy lose their healthy green color, become at first yellow only in spots or blotches, but finally so throughout.

Occasionally a plant is so afflicted that it grows but feebly, and while pushing the normal number of leaves they remain small and are badly specked before unfolding. The whole plant has a very sick and stunted appearance, and, of course, is worthless. Plants that are spotted in a less severe manner may recover after a time when removed out of doors. The dropsy seems to be the worst in early spring after the young plants are in the pots and six inches in height, bearing a dozen leaves or so.

* Prepared for the Botanical Club, Madison, Wisconsin, August, 1893.

The most frequent form of the trouble is when the translucent dots are along the veins; this being true in particular of those plants which suffer most and are dwarfed beyond their fellows. Occasionally the leaves will be only partially unfolded, and the upper border brittle and without its normal color; but as a rule the blotches and pimples are quite evenly distributed, that is, no one-half or quarter being affected to the exclusion of the other parts.

It is true that in some leaves the parts bearing the bulk of the specks are between or farthest from the veins, while in others the trouble is quite generally confined to the veins. This may be a varietal effect or possibly due to age of leaf when first afflicted. Again, sometimes the blotches are exceedingly irregular in outline, and in others almost circular and quite uniform. An affected leaf is shown below in Figure 72.

Fig. 72.
Leaf of dropsical pelargonium.

The reason for this unhealthy condition of the pelargoniums is most likely to be found in the circumstances under which they are being grown. Prof. Atkinson has met with a similar trouble which he calls edema of the tomato, and treats fully in a recent station bulletin. He concludes that the tumors of the tomato plant are due to the excess of water favored by insufficient light, that is, a wet soil and a soil temperature near that of the air. The long nights, short days and cloudy weather of late winter induce the dropsical trouble, especially with a wet, warm soil, thus making root action excessive. The remedy would seem to be in providing a cooler, dryer soil with increased light for the aërial parts, whenever possible.

Notes Upon a New Exobasidium.*

The genus Exobasidium is interesting in standing almost alone as containing parasites in the large group Thelephoreæ of the Hymenomycetous fungi. Authors have differed as to the place the genus should hold in the classification, but Saccardo, ignoring the views of Schrœter and others, disposes of it as above stated. He describes eleven species, eight of which, according to Farlow's Index, are American. Of these only one is upon a host outside of the Heath family, namely, *Exobasidium Symploci*, E. & M., on *Symplocos tinctoria*, L'Her. The American species on Ericaceæ may be tabulated with the hosts as follows:

1. *Exobasidium Vaccinii* (Fl.), Woron.
   On *Arbutus Menziesii, Arctostaphylus Uva-ursi, Cassiope tetragona, Gaylussacia resinosa, Rhododendron viscosum, Vaccinium macrocarpum, Vaccinium uliginosum, Vaccinium Vitis-Idœa.*
2. *Exobasidium Andromedæ*, Pk.
   On *Andromeda ligustrina.*
3. *Exobasidium Azaleæ*, Pk.
   On *Rhododendron nudiflorum.*
4. *Exobasidium discoideum*, Ell.
   On *Rhododendron viscosum.*
5. *Exobasidium Cassandræ*, Pk.
   On *Cassandra calyculata.*
6. *Exobasidium Arctostaphyli*, Hark.
   On *Arctostaphylos pungens.*
7. *Exobasidium decolorans*, Hark.
   On *Rhododendron occidentale* and *Rhododendron viscosum.*

The seven species have twelve hosts, and *E. Vaccinii* has two-thirds of all. Three species are confined, as far as yet known, to a single host each, and *Rhododendron viscosum* bears three species.

From an economic standpoint the *E. Vaccinii* is the only species destructive to any crop, namely, to the cranberry. During this summer samples were sent me from Massachusetts asking for a remedy, the young stems being much distorted by the fungus.

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*Read before the Botanical Club, A. A. A. S., Madison, Wis., August, 1893.

The members of the genus as a rule are conspicuous, the general characteristic being a much-swollen leaf or branch. The common azalea or pinxter flower (*Rhododendron nudiflorum*) is known in many places as the "Swamp Apple," because so generally producing upon the tips of the branches swollen masses, large as, and superficially somewhat resembling, green apples, the work of *E. Azaleæ*, Pk. In the same genus on *Rhododendron viscosum* is *E. discoideum*, Ell., which develops upon the under surface of the leaves large, turbinate or discoid galls two or more centimeters in diameter. The *E. Vaccinii* upon some hosts causes the stem to enlarge to many times its normal size. Galls of *E. Andromedæ*, Pk., are cupuliform and lobed, the hollow cavity containing cottony fibers and are, as the author states,* "lateral or rarely terminal on living branches, transforming the leaf buds."

On the 30th of May last the writer's attention was attracted to a group of *Andromeda Mariana* plants in a roadway near Farmingdale, N. J. The tips of the stems, instead of bending somewhat to one side and hanging full of the large white corolla bells characteristic of the species, were bolt upright, shorter than usual and bearing capitate masses of a pale-green color. Upon inspection these were seen to be abnormally-developed stems with their misshapen flowers in dense clusters. Some of the stems bore ordinary flowers a few inches below the malformed tips.

An examination assured me that the strange forms were due to an Exobasidium, and not being able to make it fit into any of the species described, was constrained to send specimens to Professor Peck, who is the author of three of the American species of Exobasidiums, including the one upon Andromeda above mentioned. He reported it as unknown to him. It is therefore with much pleasure that this second Exobasidium upon the Andromeda genus, the first bearing the generic name Andromeda by Professor Peck, is to be called *Exobasidium Peckii*, in honor of a life-long faithful laborer in American mycology.

This species is remarkable in being confined almost entirely to the inflorescences, where it causes most extravagant enlargement and distortion of parts. Some of the single flowers are more than an inch in length and in spread of petals, the bell-shaped corolla being replaced by one that is wheel-shaped and polypetalous. A full study of all the abnormal floral organs might show points of structure of ordinary

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* Twenty-sixth Report of New York State Museum.

blossoms with added clearness, and possibly throw light upon obscure parts. The ovary, for example, is raised half an inch or more above the receptacle and the peculiar placentæ greatly exaggerated.

Figure 73 is made from a photograph of a group of a healthy and

Fig. 73.

Exobasidium Peckii, Hals., causing polypetalous flowers in *Andromeda Mariana*.

an affected branch, and shows the abnormally-exaggerated almost polypetalous flowers in striking contrast with the corolla bells of the ordinary form.

REPORT OF THE ENTOMOLOGIST.

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REPORT OF THE ENTOMOLOGIST.

JOHN B. SMITH.

GENERAL REVIEW.

The season of 1893 has not been remarkable for any severe outbreak of insects, although a very great deal of damage has been done, as usual. In the work that was planned for the year, an investigation of root maggots, the completion of the life history of the sweet-potato flea-beetle and the discovery of the alternate food plants of the melon-louse held leading positions. Quite early in the season, several trips were made to Swedesboro, at which point flea-beetles were most numerous. A large number of plants were examined in the field with the utmost care, many other plants were taken and examined in the laboratory, while yet others were brought in and grown in jars to furnish food for the beetles collected for experimental purposes. Between one and two hundred beetles were collected, in the hope that eggs and larvæ might be obtained. They were placed upon the plants growing in jars, fed freely and copulated readily. After the beetles had died off, which occurred in about ten days after they were brought in, the plants were taken out and washed, as was also the sand in which they were grown; but, in spite of the care with which the search was conducted, neither eggs nor larvæ were found. Nor did I succeed in finding on the plants brought in from the fields, where flea-beetles were in any quantity, any specimens of larvæ. The nearest approach to anything that might be considered as the work of the larva of this species was in some of the finer root fibers, which appeared to have been eaten out; but I found nothing that would give me absolute certainty. I am inclined to believe, although it is a belief not supported by proof, that the early stages are passed in these small rootlets, of which there are an enormous number on the sweet potato plants. Two facts were learnt: The first is, that the beetles make their appearance again in midsum-

mer; and the second, that they continue on in small numbers during the balance of the season and pass the winter in rubbish of any kind that they can find. Specimens have been sifted from the debris found in the nests of field mice gathered in January, and it is very probable that in such places and in similar localities the winter is passed. This information does not affect the recommendations that have been made as to remedies, and what has been published in the last report applies as before. There was considerable injury to sweet potatoes during the present year by cutworms, though they were not so abundant, locally, as during 1892.

In the hope of discovering the alternate food plant of the melon-louse, I made several trips to Port Monmouth and various points in Cumberland, Gloucester and Salem counties, but without meeting with the desired success. I carefully examined vegetation of all kinds in the localities visited, and collected a very large number of species of plant lice, which were carefully examined, whenever they showed the slightest tendency to resemble the species sought for; but I did not find a single specimen of the desired species. Quite late in the season, a very few specimens were found on the melons, but no injury was done, the creatures not seeming to find the temperature or other weather characteristics suitable for rapid increase. I did not receive from any locality any complaints of injury from this insect. The remarkably cold winter of 1892–93 had the effect of very greatly reducing the number of two of the melon pests—that is, the "boreal lady-bird" and the "squash-bug," neither of which was as abundant this year as it was in the past. Indeed, the lady-bird was, comparatively, a rarity in the localities that I visited. Little additional information was gained concerning the squash-borer, which also seemed to be less abundant than during some previous years. It was, however, determined that a small percentage of larvæ transformed to adults in the fall of the same year, but these are unable to reproduce their kind because there is no time for a second brood of larvæ. It was also determined that, normally, the larvæ remained in the cocoon unchanged during the winter, transforming to pupæ only a very short time previous to their emergence as imagos in spring.

Onions are grown on quite a large scale in Cumberland county and also in parts of Warren county. On a smaller scale, they are grown throughout the State, and in many localities they suffered severely from the root-maggot. How to deal with this insect has been a ques-

tion, and none of the remedies that have been suggested have proved satisfactory in all cases. The Entomologist is under a very serious disadvantage in studying forms of this kind, because he has no facilities for growing plants, and therefore no opportunity to make any satisfactory tests with insecticides on insects of this character. It was the intention to find some grower on whose land the onion-maggots were rather plentiful, and to carry on experiments there, under ordinary field conditions, which would have, of course, given the best and most satisfactory tests of the substances applied. Quite early in the year, Mr. Theo. D. F. Baker, of Bridgeton, wrote that the maggots had suddenly made their appearance in his land in very large numbers, and he asked for suggestions. This was rather a surprise to me, because Mr. Baker had stated positively during the preceding winter that no trace of the onion-maggot had been theretofore seen on his land. He repeated this statement, and added that he has known the insect from other localities and felt positive that this was the first appearance in his fields. Nor did any of his neighbors seem to have known of it until the present season. The appearance in such numbers, therefore, was a matter of some surprise. Fortunately, the growers of onions in that immediate vicinity were fully alive to the consequence that might result from the increase of the insect, and they at once adopted heroic measures. The entire fields were gone over, row by row, and all plants that showed signs of infection were taken out bodily and afterwards destroyed. Then heavy dressings of kainit were applied, with the result that no further traces of these maggots were seen at any time later in the season. Another insect which had not been previously noticed in any number was the onion-thrips. This little creature was on the leaves in perfectly astounding numbers. The result of their eating was visible in the form of small yellow spots, increasing in size until the tips of the leaves became yellow or brown, and, finally, the whole stalk had a whitish appearance, very different from the usual dark green of a healthy onion plant. Some experiments were made later on with fly larvæ, which resembled those of the onion-maggot and were at first mistaken for them, and these will be found detailed at some length further along in the report. I am strongly inclined to attribute the cessation of the attack and the absolute absence of a second brood to the very active measures taken as soon as the insect was discovered, and as all the growers combined in the campaign, the result was complete. It

furnished an object lesson of no mean value, as to the possibilities in the way of controlling insect injury, where intelligent, systematic and combined efforts are made.

A somewhat unlooked-for occurrence was the appearance of the "wheat-head army-worm," in some numbers, in Hunterdon, Mercer and, perhaps, one or two neighboring counties, where they did a very considerable amount of damage by eating the kernels of grain, in whole or in part, scattering them over the field so as to make it "look like a threshing floor," as one farmer expressed it. This is an insect that appears in some numbers each year, though it is very rarely, indeed, noticed by the farmers. The circumstances that led to its unusual increase during the present year have not yet been satisfactorily explained.

Great damage was done by the Angumois grain moth, during the winter of 1892–93, to grain stored in the mow, or left out in the fields until late, before being threshed. In parts of Burlington county, where this insect was most troublesome last year, many of the farmers followed this year the advice given by the Entomologist and threshed their grain as soon as it was harvested. In a few localities, the wheat louse made its appearance in small numbers, and in some cases produced uneasiness; but nowhere did it become numerous enough to do any perceptible injury, its natural enemies sufficing to keep it in check.

Corn suffered quite severely from insect attack of various kinds. Cutworms were unusually abundant, and much replanting was made necessary by their attacks. During the few years last past a "root webworm" has been becoming more and more abundant, and this year did very serious injury throughout the southern counties and extending northward into the center of the State, at least; how much further, I have no means of ascertaining, from lack of reports from that section. This "webworm" is originally a grass insect, and is very similar, if not identical, with one that feeds on and in roots of plantain. It is therefore on old sod land that it is very much more abundant than elsewhere, and, in fact, other fields are quite usually exempt. It is also a fact, which I was enabled to verify this season in several instances, that where the mineral fertilizers had been used, very little or no injury appeared, even where the corn was planted upon old sod. I am distinctly inclined to attribute this difference to

the use of the mineral fertilizers, and consider it another argument for their more general employment.

Of the "corn bill-bug" I heard comparatively little during the present season, and, apparently, some natural check existed in most localities, preventing its usual increase. I am as little able to suggest the nature of this natural check as I am to explain what check was removed to enable the "wheat-head army-worm" to increase so remarkably.

A pale flea-beetle, *Systena blanda*, has been for some years rather a common species on a great variety of plants, both cultivated and uncultivated, and on one occasion within my experience it did some damage to beans; but it has never proved anything really serious. Near Bridgeton, in Cumberland county, it increased in a remarkable way during the present year and became destructive. Almost every field of carrots was absolutely and completely destroyed by these insects, the young plants being eaten down to the ground as soon as they appeared above it. Young beets suffered to a less extent, affording a much larger leaf surface for the pests to feed upon. Melon vines were more injured by them than by their usual foe, the "striped beetle." Even the weeds were infested, and pigweed was an especial favorite, the leaves being riddled and the plants in some instances killed. If we could induce this insect to confine its attacks to the pigweed we might become reconciled to its increasing numbers.

The "strawberry-weevil" has been troublesome in Delaware and southward for two or three years past, and has been studied by Prof. Beckwith and by Dr. Riley. The species has been collected in this State, but up to the present year has not been known as injurious to strawberries. This year, however, it did some injury both at Bridgeton and Vineland, in Cumberland county, and there is a possibility that there may be increasing trouble for some time to come. The strawberry has, in this State, been quite remarkably free from insect attack, and it would be much to be regretted if this crop should also become one for which the farmers are compelled to fight with the insect pests. There is not, unfortunately, any method of procedure which can be recommended to prevent the spread or appearance of this insect, and we can only hope that the same force that influenced its increase will also again cause its disappearance. That this hope is not without a reasonable base in this particular instance, is proved by the fact that a few years ago I found the insect excessively trouble-

some on Staten Island in one year, while in the following years there were few or no specimens appearing.

The spread of the "pear midge" in this State is a subject that of course demanded attention, and I have been able to ascertain that it has reached Monmouth county. I found a number of infested pears on a Lawrence tree near Port Monmouth, and had it reported from a number of new orchards in the vicinity of New Brunswick. How much further it has extended I have not been able to ascertain, and one reason for that may be, that the Lawrence set very heavily in most localities during this season, and quite a considerable percentage might have been infested without attracting the attention of the farmers. It is also within the bounds of possibility that there was no very great spread during the present year, because the excessive number of blossoms furnished an abundance of opportunities for the midges to lay their eggs, and therefore migration was unnecessary. At my suggestion, Mr. J. M. White, of New Brunswick, whose orchard became infested last season, applied a very heavy top-dressing of kainit under the infested trees, with the result that this year his orchard was practically free from the midge, while in the neighboring orchard, which was also infested last year, and where no measures of any kind had been taken, every Lawrence pear was destroyed, while many of the Bartletts were also attacked. A series of experiments made by me proved to demonstration the beneficial effects of certain fertilizers as against this insect. The details of these experiments will be given further on in the report.

Among the most troublesome insects infesting pears in other States is the pear-psylla, which has been studied in New York State by Mr. Slingerland. Up to the present year no trace of its presence has been found in New Jersey. Early in the fall of this year, I received, much to my regret, specimens of this insect from a nursery in Burlington county. In order that this insect might be recognized by growers, and that proper measures may be adopted to check its advance, if indeed an advance is made, a brief compiled description of the insect and its life history is given further on in the report.

The new asparagus-beetle which was mentioned in the report for 1892 has continued to spread in the State. I found it again in Gloucester county this season, and found also a few specimens at Bridgeton, in Cumberland county. I am informed by the Philadelphia collectors that they have taken it near Gloucester and also in the

vicinity of Camden. Thus far the insect does not seem to increase fast enough to do any real injury, and no account will be given, attention being merely called to the matter to show that it is being studied and that the insect is spreading. One of the more difficult matters in the treatment of the old asparagus-beetle has been the protection of young plants from the attacks of both beetles and larvæ, and the application of lime has been about as effective as anything that has been tried. I saw at Port Monmouth, on the farm of Mr. Roberts, a practice that is at once simple and effective. The grubs or larvæ are very soft, slimy creatures, sluggish, and able to move on the ground at an exceedingly slow pace only. The sand in which the asparagus is usually planted becomes, in the middle of a bright day, almost burning hot, and by simply brushing the asparagus rows with a round stick so as to dislodge the larvæ and cause them to fall to the ground, they can be completely cleared. The burning sand kills the slugs long before they have an opportunity of making their way back to the plants from which they have been thrown. Mr. Roberts has found this effective practically, and I tried it experimentally. I found that the insects could be very easily dislodged from the plants upon which they were feeding, dropping quite readily where a stick was brushed over and through the foliage. I found, too, that the great majority became bloated and helpless before they had marched an inch over the hot sand, and that in a very few minutes they were dead. This proceeding is at once inexpensive, simple and effective. To obtain the best results the middle of a hot day should be chosen, and the plants should be cleared before they are tall enough to cast sufficient shade upon the ground to shelter it from the rays of the sun.

Potatoes have suffered as usual from the Colorado beetle, and more than usual from flea-beetles. In fact these little pests have become so numerous, and so troublesome during the two or three years last past, that they are really doing almost as much injury as their better-known relative. Other insects which also attacked potatoes this year were the "blister-beetles." These appeared in much larger numbers than for many years previous, and while many farmers claimed that they had never seen them before, others, with better memories, or more observing, said they were the "old-fashioned potato-beetle," which used to be troublesome before the Colorado beetle made its appearance. These blister-beetles appeared suddenly, in very large numbers, and

remained comparatively only a short time. Fortunately we are able to give some sort of explanation for the increase of these species, and a brief account of the life history and habits of our common species appears in this report.

Cranberry insects continue to exact their tribute each year, and at the meeting of the American Cranberry Growers' Association, which I attended, there was the usual complaint of injury from grasshoppers. The apparent facts as they are observed on the cranberry bogs are so strong that many growers refuse to accept the conclusions in Bulletin No. 90, and still believe that grasshoppers rather than katydids cause the injury. To again test the matter I accompanied a little party of growers to an Atlantic county bog, where it was claimed that grasshoppers were doing serious injury. The result was only what I had expected, and confirmed in every respect all the conclusions of my published reports. Not one of the growers was able to show me a grasshopper which had eaten anything but grass tissue, and in the many specimens of which I examined the stomach contents, not a trace of cranberry seeds could be found; but on the contrary, and much to the surprise of the gentlemen, katydids proved to be very plentiful, where they had been almost unnoticed, and every solitary katydid had its crop and stomach full to their utmost capacity of cranberry seeds. It was, of course, impossible to resist the conclusion that was evident upon the face of the facts, and yet the old adage that "A man convinced against his will is of the same opinion still," proved itself true again in the present instance. So firmly fixed is this belief that grasshoppers are the authors of the injury, that even the plainest facts failed to remove it entirely. One suggestive fact came out in the discussion of this subject, and that is that a flock of turkeys had been used with excellent results, by one grower, to destroy the Orthoptera on his bogs. This is in line with recommendations made by me in Bulletin K, and offers the most promising solution of the difficulty.

Cranberry-growing is becoming an industry of some importance in Wisconsin, and recently the Horticulturist of the Wisconsin Station published a bulletin compiled from reports and bulletins of the New Jersey Stations, for the information of growers of that region. At a meeting of the Economic Entomologists, held at Madison, Wisconsin, which I attended in behalf of our Station, I learned of a very interesting point of difference in the life history of the *Teras*, in that State,

as compared with its cycle in New Jersey. In our State the winter brood of this insect is slate-colored, while the two summer broods are of a bright orange color. In Wisconsin, it is said, the orange-colored form disappears, and only the slate-colored form is known, both in the summer and winter broods. This is interesting if not quite unexpected, and it illustrates the effect of climatic influences upon an insect. Another interesting bit of information was received from Mr. A. J. Rider, the Secretary of the Cranberry Growers' Association, who sent me a few bright specimens of the "fireworm moth" (*Rhopobota*), which were sent him from the State of Washington, where also cranberries are now grown. Inquiry showed that the plants that were set out on the new bogs were obtained from Cape Cod, Mass., and this explains at once the appearance of these insects on the bogs there. The eggs which lived through the winter were almost undoubtedly on the leaves of the plants sent to be set out, and as a result, with the new crop, its insect enemies were also introduced. This is one of those cases where prompt measures would prove effective in exterminating the insect from its new locality, and a small sum expended at the present time would mean a very large saving in the future.

The use of photography in illustrating insects and their work has occupied a portion of the time of the Entomologist, and many good negatives have been obtained. It is obvious that a good picture will be much more easily understood than any possible description, and many of the illustrations used in the reports of the Botanist as well as of the Entomologist are made from photographs taken in the laboratory. An immense advantage is gained by being able to fix permanently such insect injuries as cannot be preserved, dry or in alcohol, or which lose their characteristic appearance rapidly.

The question of legislation for the prevention of insect attack was discussed by the State Horticultural Society at their meeting in December, 1892, and a Committee on Legislation was appointed. As this matter had been studied to some extent by the Entomologist of the Station he was appointed a member of this committee to consider and prepare the terms of such a law as would prove applicable to the condition of affairs in the State of New Jersey. A full and careful examination of the legislation of other States in this matter was made, and an act was drafted which it is believed may be enforced

whenever the public opinion in any county is in sympathy with the object of it.

Finally, a few words may be added concerning the exhibit made by the Stations at the World's Columbian Exposition at Chicago. To the Entomologist was intrusted the preparation of this exhibit, and for the purpose of obtaining material, &c., the New Jersey Commission, appointed by the Governor, appropriated a sum of $650. With this sum an exhibit was prepared which compared very favorably with anything shown by other stations. From the Chemical Department was shown a very complete exhibit illustrating the composition of milk of the leading breeds of dairy cattle, and also the amount of food required by each breed to produce a given quantity of milk, butter-fat and total solids. The exhibit made by the Biological Department was of oyster culture, and is fully described in the report of the Biologist for 1892. The exhibit made by the Entomologist was also briefly described in that report. The Farm exhibit was confined to photographic views of the buildings and of the experiment herd, each cow being separately shown, and the name as well as the register number given. In addition, views of the Laboratory and of the Station staff complete this feature of the exhibit. At the request of the Director of the Office of Experiment Stations, in Washington, the Entomologist took charge of an entomological laboratory, illustrating an ample outfit for an experiment station, and this proved not the least interesting portion of the exhibit. It is expected that the material prepared will, when returned, form the nucleus of a State collection of agriculture.

As usual, the Entomologist has been called upon for talks and lectures at County Boards and farmers' meetings, and the correspondence of his office has steadily increased. At a meeting of the County Board of Monmouth county, the subject of spraying was very fully discussed, and it appeared that most of the progressive farmers had adopted the practice; also that each year a greater number of agriculturists were coming into line, finding profit in insecticide applications. In every case satisfactory results have been obtained. A new feature in presenting insect topics before farmers' associations has been the use of the stereopticon or projecting lantern, with slides made from negatives secured at the Station, and this will add both interest and greater value to such lectures in the future.

Entomology in the "Crop Bulletin."

As was the case during the preceding year, great advantage was gained both by the farmers and by the Entomologist from the Crop Bulletins of the State Weather Service. They were used by the Entomologist to convey a certain amount of information to the farmers, and on his part benefit was derived from the records that appeared of the occurrence of insects at different times in all parts of the State. The items published are again deemed of sufficient importance to warrant a review of what appeared during the year.

May 15th, the Entomologist announced the lines of study that he desired most to pursue, asking co-operation, and on that day reports from Egg Harbor City and from Raritan township stated that spraying had begun. On the same date, Mary H. Lee reported from Vineland, "a small, black beetle working on strawberry blossoms," and this, by the by, was the first intimation I had of the occurrence of this insect in the State.

May 22d, Mr. H. Y. Postma reported from Egg Harbor City that "caterpillars are doing much damage to fruit." Mr. T. J. Beans, of Moorestown, reports that "plants removed from hot-beds to open fields are being seriously injured by cutworms." Mr. H. I. Budd, of Mount Holly, reports that "grubworms are badly cutting off sweet potatoes, tomatoes and other plants." Mr. Henry A. Jorden, of Bridgeton, reports "some damage to strawberries by a bug, but to no extent." From Monmouth county, Mr. J. Statesir reports that "potatoes are coming up, and many bugs made their appearance during the warm days." From Ocean county, Mr. Harry M. Bunnell reports, also, that "potatoes begin to show themselves, and with them potato-bugs in good numbers."

On May 29th, the appearance of "potato-bugs" is reported by Mr. D. T. Atwood, from Bergen county; Mr. J. Q. Hoagland, of Hunterdon county; Mr. Joseph A. Yard and Mr. J. Statesir, of Monmouth county. Cutworms were marked "troublesome" from Bergen county, where they were reported as generally injurious to plants and truck. From Burlington county, they were reported both as "generally injurious" and as "particularly troublesome to tomatoes." In Gloucester county they "troubled sweet potatoes," and in Warren county they were said to be "very troublesome to corn." From Vineland, Mary H. Lee reports "apple trees are badly troubled with

worms," in some sections. Mr. John Bellis, of Kingwood, reports that "the tent-caterpillars, and the currant-worms have made their appearance." Mr. Ketcham, of Mercer county, reports "a new insect on currant leaves, giving the appearance of blight and threatens trouble." Mr. C. M. Norton stated that at Hightstown "wireworms are very active." The "corn bill-bug" was again complained of from Monmouth county, and "flea-beetles were injuring sweet potatoes" in Salem county.

June 5th, "worms and potato-bugs" were said to be "very troublesome," by Mr. Richardson, of Beverly. The "ravages of cutworms" were said to be "the most harmful of adverse causes," by Mr. Beans, while the "webworm, bill-bugs, wire and cutworms" were said, by Mr. Budd, to be "making sad havoc with young corn and other plants." It was also said that "the black louse was destroying the foliage of shrubs and leaves of cherry trees, infesting dock and other weeds." Mr. Rodewald, of Pensauken, says that "cherry trees are overrun with insects." From Vineland, Mary H. Lee said that "farmers report great destruction by cutworms;" while at Bridgeton, "bugs are doing great damage to tomatoes." From Essex county, Mr. H. Jeroleman reports that "the weather has been greatly beneficial to all manner of insects, such as the apple, cherry, peach and plum louse; also a new louse on currants." From Hunterdon county, Mr. Dilts reports that "many complain of injury to corn by cut and webworms," and also that "cutworms are troublesome to potato plants." Mr. John W. Horn, of Mount Airy, states that "since last report corn on sod has suffered greatly from ravages of the cutworm, whole fields being completely destroyed by this pest, and replanting is absolutely necessary." From Locktown, it was reported that "webworms were doing great damage to corn, some fields nearly all destroyed." In Pennington, it was reported that "corn-planting was nearly finished, and cutworms are making havoc with early planting." From Titusville, it was said that "webworms are doing some damage." In Hightstown, there was "much complaint of wireworms and bill-bugs on corn; one field, twenty-two acres, is being furrowed and replanted for the third time." In Metuchen, it was said that "potato-bugs abound." In Farmingdale, "corn came up well, but is being eaten up by cutworms." In Ocean county, "truck is somewhat injured by numerous insects." From Paterson, we learn that "potato-bugs have appeared in large num-

bers," and that the "cutworm is also reported in unusual numbers." In Somerset county, "corn came up poorly and what is up cutworms are eating badly." From Plainfield it was briefly stated that "insects are attacking fruit trees."

June 12th, currants were somewhat injured by worms in Bergen county; cutworms were still destructive in Burlington county, and some corn and tomatoes required replanting in consequence. So, in Camden county, it was said that "worms are still very troublesome." In Cumberland county the weather was said to be "good for potato-bugs," and in Vineland, "cutworms are very bad, and rosebugs appeared in some sections." In Essex county, both "potatoes and potato-bugs" were said to be up to the average. At Swedesboro, "sweet potatoes looked badly on account of fleas and cutworms." In Hunterdon county "the worm pests continue at the corn and are doing much damage." "Potato-bugs are very numerous; tent-caterpillars and currant-worms are numerous," while "corn planted on stubble," it was said, "escaped the cutworms and looks fairly well." In Mercer county, "corn is still damaged by worms in some sections, making entire replanting necessary;" and it was also generally stated that "insect pests are still active, and rosebugs have been added during the week." From Metuchen, it was reported that "flea-beetles by the million are eating the potatoes, plant lice abound and rosebugs have come." In Ocean county, "worms and insects were very bad," while reports from Passaic county stated that "potato-bugs are getting too numerous," and that "potatoes are having a hard struggle with the bugs."

June 19th, it was reported from Bergen county that "grapes are already damaged to some extent by the rosebug." In Burlington county, "webworms are cutting corn some." In Camden county, "insects are said to be not as numerous as some years, while from Woodbine, in Cape May county, comes the statement that "the cutworm has not been here." In Gloucester county, "sweet potatoes look bad on account of bugs, fleas and dry weather." At Mount Airy, Hunterdon county, "the cutworm was not so numerous as last week," while it was doing considerable damage to the corn at Kingwood and Readington. At Metuchen, it was said that "flea-beetles and potato-bugs are busy at work; lice infest cherry, plum and other trees; rosebugs abound." In Morris county, "cutworms are working diligently in corn-fields." In Ocean county, "rosebugs are doing great damage

to fruit trees," and in Passaic county, insects were also said to be "more than plentiful on all fruit trees."

On June 26th, Mr. Dilts reported from Ringoes that "corn is very uneven on account of worms and drought." Mr. Doty, from Sussex county, reports "cherries, especially the early ones, stung by insects; corn looking well where not injured by grubs, and early potatoes in blossom and lots of bugs on them."

July 3d, two reports from Cumberland county state that "worms are cutting young tomato plants." In Hunterdon county, Mr. Bellis reports that "a green worm is eating corn and doing damage in some rye-fields," while Mr. Lequear said that the wireworms are bad in corn. From Metuchen, Mr. Marshall reports "rain, sunshine, growth, joy, bugs, flea-beetles, lice, leaf blight and vigilance." From Mercer county, two reports show "injury to wheat by a greenish-colored worm; some farmers say that one-third of the crop is destroyed." In Sussex county, "onions are looking fine on uplands, but on lowlands they are greatly injured by wireworms, and are a little backward."

July 10th, Mr. Beans reports from Burlington county that "many propose early threshing because of the grain moth." From Hunterdon county three reports complain of a worm eating the grain, and Mr. Hoagland states that "this worm has done great damage to wheat; from one to five kernels in each head partly eaten." "The drought of two weeks ago seems to favor worms." Web-caterpillars were said to be "quite numerous," by Mr. Fleming. From Mercer county Mr. Ketcham reports that "webworms disappeared when the corn hardened; but did great damage." Mr. Blackwell stated that "the damage to wheat by worms, and of salable corn, will amount to nearly one-tenth of the crop, the visible damage being in the cut grains." "The wheat-fields look as if bran had been sown." From Warren county it is reported that "corn has not fully recovered from the ravages of the cutworm."

July 17th, Mr. Beans again reports that "some wheat is threshed directly from the fields." In Cumberland county "the tent-caterpillar is troubling fruit trees very much." In Essex county is was said that "the caterpillars are not eating the grapes this year like they did last, and there will be an abundant yield of fruit." From Hunterdon county Mr. Bellis reports that "the web-caterpillar is doing some damage to fruit trees," and Mr. Lequear states that "potato-bugs are

not so numerous; no rosebugs; but some fields of corn are hurt by a slender, brown worm without web." In Passaic county the potato-beetle only was complained of, and in Warren county it is said that "buckwheat is nice, where it was sown in corn-fields, after the worms destroyed the corn."

July 24th, Hunterdon county reports that "canker-worms seem to have stopped webbing," and from Middlesex county corn is said to be "uneven, and in many places worms have troubled it so that most fields are spotted."

July 31st, Hunterdon county reports that "some are threshing wheat and report a poor yield, owing to the ravages of the army-worm." In Ocean county "grasshoppers are doing much damage to newly-planted cabbage;" "vineworms are eating the leaves of field corn worse than last year;" and "it is reported in Jackson township that the fireworm is at work on the cranberry bogs."

August 7th, Bergen county reports that "sugar corn is being injured by the grubworms." In Ocean county it is said that "the cool weather has driven away grasshoppers," and that "the white butterfly which flits around cabbage has not so far made its appearance."

On August 4th there is no direct report of injury; but Mr. Bunnell reports from Toms River that "fruit is faulty, owing to the indifference of farmers in spraying." From this time to the end of the season, weather conditions were such that the damage done by them overshadowed everything else, and there seemed to be no further reports of troubles from insects. The cyclonic storms, heavy rains, following a period of severe drought, probably caused as much injury in the course of two or three weeks as insect attack did during the entire year.

The Pear Midge.

(*Diplosis pyrivora*, Riley.)

In my report for 1891, I first gave an account of the appearance of this insect in New Jersey, and concluded, from the observations made, that the insect had been within the State limits for some time. I gave on that occasion the history of the insect, so far as I was acquainted with it, and gave also a brief account of its life cycle, with some sug-

gestions as to the character of the measures to be taken to control its spread. Since that time this insect has been under close observation, and I have watched its increase and spread with interest, and with the object of discovering, if possible, a reliable remedy or method of checking its advance. During the present year I have continued these observations, and have also made a series of experiments that were indicated by my previous studies, and these experiments have resulted quite satisfactorily. As the insect had already reached New Brunswick two years ago, I had a good opportunity for observing it; and as Mr. White, in whose orchard it made its appearance in small numbers, was quite willing to adopt any suggestions made by me, I had an excellent chance to test, in a practical manner, such suggestions as seemed theoretically indicated. The field experiments thus made resulted quite as successfully as did my laboratory experiments, and the midge was practically exterminated from Mr. White's orchard. During my various excursions to different parts of the State, I kept a close lookout for signs of the midge, and found that at Port Monmouth, two Lawrence trees, in an orchard not far from the railroad station, were infested by midge larvæ. I found, also, that the insect had made considerable spread in the vicinity of New Brunswick, and that many orchards in which it had not been previously noticed, were badly infested during the present year. In 1892, Mr. White's orchard showed a considerable number of trees of the Lawrence variety, on which midge-infested fruit was found, and as stated in my report for 1892, the adjoining orchard was very badly infested. At my suggestion Mr. White gave his entire pear orchard a heavy top-dressing of kainit, applying it under the infested trees at the rate of over 1,000 pounds to the acre; but of course this proportion was not kept up in other parts where the midge had not been noticed. Early during the present season, when the pears were of a size sufficient to show the presence of the midge, I made a very close examination of Mr. White's orchard and that adjacent to him and the result was quite remarkable. Lawrence pears had blossomed and set very heavily; but in the neglected orchard I failed to find a single fruit that was not infested by midges, and so abundant were these creatures that they overflowed to the Bartletts and to other varieties in this orchard. On the other hand, in Mr. White's orchard, the most careful search discovered only two infested pears and those at the points nearest the old orchard. The exemption

was really most astonishing, because not fifty feet from one corner of his orchard was a Lawrence tree full of fruit, every solitary one of which was full of midge larvæ. Of course trees so infested were a distinct menace to Mr. White's orchard, and it gives me pleasure to say that it needed only a fair representation of the facts to induce the owner of the trees to consent to their being stripped of all fruit in order to destroy the larvæ contained in it. I attributed the exemption enjoyed by Mr. White entirely to the application that he had made at my suggestion; but in order that the matter might be more fully tested I carried on a series of laboratory experiments, material for which was easily obtained from the infested orchard on June 10th. Between 200 and 300 specimens of infested pears were collected; a portion of them were placed in a breeding-jar for future use and for such experiments as might be required, while the balance was divided among eight one-quart jars, half filled with sand. The pears were distributed among these jars with the idea of getting a nearly equal number of midges into each, and a rather careful selection was made of the specimens to that end. These jars were left undisturbed, except that the sand was occasionally moistened with water, until August 3d. At this time the jars were all carefully examined, and it was found that from most of the pears the larvæ had made their exit and had burrowed underground a short distance, although none had, at that time, formed cocoons. Quite a number of the pears, however, had neither decayed nor cracked open and on cutting into these the larvæ were found inside, apparently in good condition. All such pears were cut open and replaced in the jars, the abandoned specimens being thrown away. Two jars were selected as checks and set aside, receiving no application of any kind. In two other of the jars a small quantity of nitrate of soda was spread dry upon the surface of the ground, to represent in the one case a fair top-dressing under ordinary field conditions, and in the other a heavy dressing, the quantity in the second jar being exactly double that in the first. The amounts were not weighed, as they were too small. Two other jars received muriate of potash, about the same quantity as in the case of the nitrate, and here also one jar received exactly double the quantity placed in the other. A third lot of two jars was treated with kainit, the amount of kainit applied in jar No. 1 being about the same as the amount of muriate applied in jar No. 2, while in the second kainit jar twice as much was applied as was contained in the first. These

eight jars received at intervals small amounts of water, sufficient to keep them moist, until October 6th. On that day all the jars except one of the checks were examined.

The check-jar which was first examined showed numerous specimens of the larvæ in the sand which had not formed cocoons, and all of these were alive and apparently perfectly healthy. There were also a very large number of cocoons containing unchanged larvæ, and these all seemed to be healthy and in condition to transform next season. In none of the other jars examined were there any living larvæ lying free in the soil, although here and there a few dried and shriveled specimens could be found, and in none of the other jars was there anything like the number of cocoons found in the first examined.

Jar No. 1, muriate of potash, found no free larvæ, but quite a number of cocoons; in bulk, perhaps, four-fifths as many as were found in the check lot, but in these nearly one-half of the larvæ examined were dead.

Jar No. 2, containing muriate double in quantity to that contained in No. 1, showed no free larvæ, and of cocoons about as many as in the first lot; but of the larvæ within the cocoons about three-fourths were dead.

Jar No. 3, containing nitrate of soda a small quantity, had no free larvæ, and of cocoons in bulk about two-thirds as many as in the check lot; but in the cocoons, so far as they were examined, not ten per cent. of the larvæ were alive, and the very great bulk of them were dried and shriveled.

Jar No. 4, containing nitrate of soda, double the quantity, had nearly as many cocoons as in the preceding; but certainly not more than five per cent. of the larvæ within these cocoons were alive.

Jar No. 5, containing kainit, a small quantity, had no free larvæ, and of cocoons about two-thirds of the check lot, or about the same as in the case of the nitrate; but of living larvæ there were less than three per cent. within the cocoons.

Jar No. 6, containing kainit, double in quantity to that in the preceding jar, had cocoons in bulk equal to less than one-third of the check lot, and I found not a single living larva in the cocoons examined by me. That is to say, not one-third of the larvæ in the jar ever formed cocoons, and those that did, seemed, all of them, to be dead.

It may be said that the examination of the jars was made as follows: The entire contents were dumped into a large pan and water was added. The pan was then shaken carefully, the dirty water with the loose material floating in it was poured off and more water was added until it remained clear. The sand was then gradually washed out, and there remained only the insect larvæ and their cocoons. These were then transferred to narrow vials of exactly the same size, in order that a comparison might be readily made, and then twenty specimens of each lot were examined, in order to ascertain the proportion of living larvæ within the cocoons. The balance of the material remaining in each vial was preserved in alcohol for any further or future examination that might be deemed desirable. Earlier in the season, a small portion of the pears set aside for general purposes were selected out in order to test the effectiveness of chloride of magnesium. The larvæ were placed in a little dish containing sand, which was thoroughly moistened with the solution of one-fourth of an ounce of the chloride in sixteeen ounces of water; twenty-four hours afterward the insects had burrowed to the bottom of the dish and were showing no signs of injury. As the sand was dry, clean water was added; and in yet twenty-four hours thereafter the insects were alive and apparently healthy. Again the sand was moistened with the solution and again it proved ineffective. A pinch of kainit was put on the surface and left to be dissolved by the moisture already in the sand, and twelve hours thereafter the insects were dead or dying.

From Mr. White's experience, and from the results of the experiments above detailed, I feel justified in concluding that we have in kainit, used rather heavily in fertilizing quantity, an efficient remedy for this insect. The application should be made under the trees as a top-dressing at any time after the midge larvæ have left the infested fruit. This means any time in the latter part of June, or somewhat later in the season. I would recommend the application being made before or immediately after a rain, early in July.

Life History.

It may be of advantage to repeat, briefly, the life history of this insect, for the benefit of those who may not have a copy of the report for 1891. The midge itself is a small, mosquito-like fly, less than one-eighth of an inch in length, with a slender body and very long legs. Its appearance is very well shown in Figure 1, *a*, which shows the female from the side. This midge makes its appearance very early in the season, at about the time the pear blossoms are fully formed,

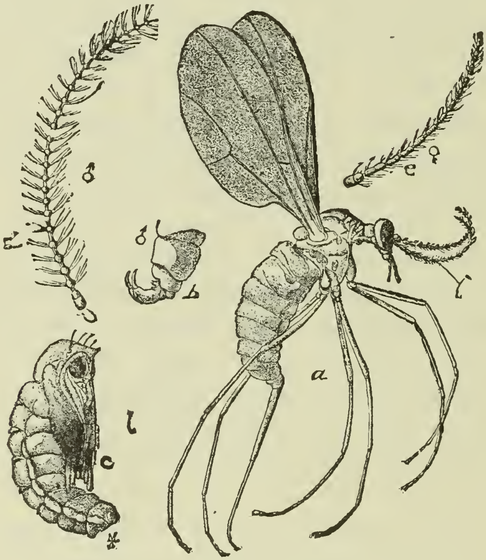


Fig. 1.

DIPLOSIS PYRIVORA.

The pear midge: *a*, the mature fly, female; *b*, tip of abdomen of male; *c*, the pupa; *d*, the male, and *e*, the female antenna. (After Riley.)

and the eggs are laid by means of the long ovipositor in the opening flowers, in the buds, or sometimes, perhaps, in the young fruit. The prime favorite with these insects is the Lawrence, and where this is available in sufficient numbers, all other varieties seem to be exempt. The eggs are laid in masses of from ten to thirty, and sometimes it appears as if more than one specimen had oviposited in the same pear; at all events forty or fifty larvæ are not unusual in a single fruit. Soon after the fruit has set, the eggs hatch, and little, yellow or

orange-colored, footless grubs make their appearance. These grow and feed upon the substance of the young fruit around the seed capsules. Early in June, when the pears are about from one-half to one inch in diameter, they stop growing, and on examination are seen to present a rough, knobby look, sometimes appearing only unusually round. With a little experience, it is possible to pick out an infested pear with absolute certainty in almost every instance. Fruit that is once infested is hopelessly lost. There is no way of reaching the larvæ while they are feeding, and the only thing that could possibly be done is to strip the tree and destroy the fruit itself. Indeed this is advisable, where the percentage of infection is very large. About the middle of June, when the larvæ are full grown, the pears begin to decay. If they are opened at this time, it will be seen that the entire inside is blackened and eaten out, and, usually after a rain, the pears crack open and the midge larvæ wriggle out and allow themselves to fall to the ground. Sometimes they crawl out to the surface of the pear and even upon the branches, especially if the latter are wet. Sooner or later, however, they draw themselves up, bringing the tail close to the head, and then give a spring, which launches them into space and usually lands them on the surface of the ground. They make their way a short distance underground almost immediately, and there they lie, resting quietly, during the balance of the season, without undergoing changes of any kind. In September or early in October they spin a thin, silken cocoon to which grains of sand are attached, and in this cocoon, at the distance of about one inch underground, the insects remain until spring. Very early in the season the larvæ change to pupæ and these transform to adult midges during the first warm days. There is absolutely no time in the entire life history of the insect when there is any opportunity of reaching the specimens so as to save infested fruit. The only chance of reaching them is when they are underground, and I think I have shown how they can be reached there satisfactorily. A very good advice is, after the application of the fertilizer, frequent cultivation, which would

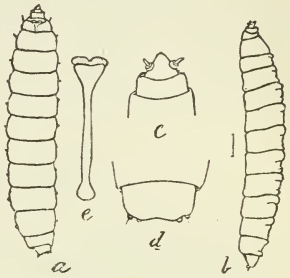


Fig. 2.

Pear midge larva: *a*, from above; *b*, from side; *c*, head; *d*, anal end of larva; *e*, the breast bone.

expose the insects or would bury them deeply and would also give the fertilizer additional opportunity to act. Cultivation just before the kainit is applied is also a very good practice, because it does not then feed the weeds or grass, and it is more certain to reach the midges or their larvæ.

The Pear-Tree Psylla.

(*Psylla pyricola*, Forst.)

This insect, which has made its appearance in our State during the past season, is one of the most dreaded by growers in New York State and in Connecticut. It is by all odds the most dangerous enemy to pear trees in that section, and it is to be dreaded in our own State as second only to the midge. Heretofore, the insect has not been found in New Jersey, and it has been considered that the State lies somewhat out of its geographical range. Commerce has done so much to spread insects that we never can tell exactly where known pests will next make their appearance; sometimes great stretches of territory are covered in one year, or an insect may jump from one part of the country to quite another without touching intervening points. It is in this way that the present species was introduced into New Jersey. Pear trees, buds or grafts purchased in either Connecticut or New York State harbored this insect in some one of its forms, and these developed and multiplied in their new home after the fashion of such pests. The insect is so important in New York State, and has been so injurious there in past years, that it has formed a subject of close investigation at the Cornell Experiment Station, and from Bulletin No. 44 of that Station most of the facts here given have been taken. I have, however, myself, collected the insect in Connecticut, and had personal opportunity of seeing the damage caused by it.

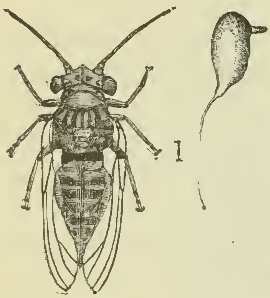


Fig. 3.
Adult pear-psylla and egg.

Classification.

The insect is one of the true bugs, or Hemiptera, and belongs to the family *Psyllidæ,* commonly known as jumping plant-lice, from the leaping habit of the adult. The *Psyllidæ* belong to the same section of the bugs as do the true plant-lice, and they have the same feeding habits, puncturing the leaves and twigs of the trees and sucking the sap.

The Injury Done.

Among the first indications of the presence of this insect in large numbers is the noticeably lessened vitality of the trees early in the season. Old trees especially put forth but little new growth. Where new growth starts, in many cases the shoots begin to droop and wither in May, as if from loss of sap. A little later, whole trees may put on a sickly appearance, the leaves turn yellow and the fruit grows but little. By midsummer the leaves and half-formed fruit frequently drop from the trees. In many cases twigs, branches and trunks may be covered with large quantities of a sweet, watery fluid, similar to the honey-dew excreted by the plant-lice. At first this honey-dew is clear, but very soon a black substance appears and spreads rapidly all through it, causing a disgusting, blackish appearance, as if the trees were covered with smoke from a factory. This black growth is a fungus which grows luxuriantly within the honey-dew, but does not attack the tree. It forms, however, with the honey-dew, a coating which must close many of the breathing pores of the leaves and thus materially affect their healthy growth. In some cases trees appear as though treated with a thick coating of paint. Distinct and prominent as are the effects of their work, the insects themselves are not so easily seen, especially in the immature or larval stages.

The Appearance of the Insect.

The immature forms are shown in Figures 4 and 5, illustrating a full-grown nymph from above and below. When first hatched they are of a translucent yellow color, hardly visible to the naked eye and rather more than one-hundredth of an inch in length. They grow rapidly, however, and undergo, gradually, changes in color and form until they measure about one-twentieth of an inch in length.

They are then oval in shape, of a general blackish color, often tinged with red, while the eyes are of a bright crimson. Very conspicuous features are the large wing-pads on each side of the body. The body itself is very much flattened, being only one-fifth as thick as long. The adult insect is shown in Figure 3, and strikingly resembles the cicada or harvest-fly in minature, being only about one-tenth of an inch in length. When at rest the two pairs of large, nearly-transparent wings slope roof-like over the side of the body. The general color is crimson, with broad black bands across the abdomen. The legs are thickened to aid the insect in leaping.

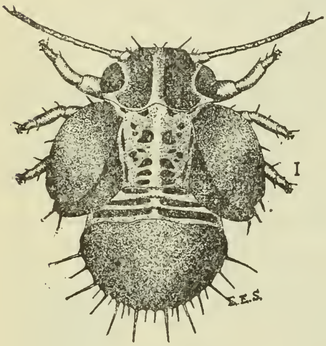


Fig. 4.
Full-grown nymph, dorsal view.

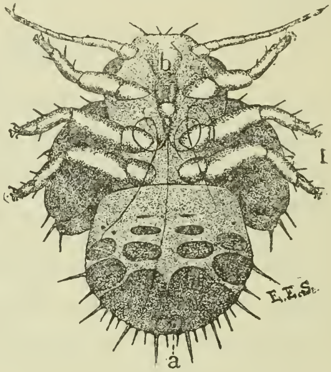


Fig. 5.
Full-grown nymph, ventral view: *a*, anus; *b*, beak.

The Life History.

This insect winters in the adult stage, passing that season hidden under pieces of loose bark, or in crevices, or in cavities formed by the bark growing about the scar of a severed limb, and both sexes are present in these hibernating forms. Very early in the spring the insects make their appearance on the twigs and branches and soon begin to copulate. By the middle of April a very large proportion of the eggs have been deposited, and soon after, or about the beginning of May, the hibernating adults disappear. The eggs are placed in the crevices of the bark or in old leaf scars, about the base of the terminal buds of the preceding year's growth, and some also about the side buds near the terminal ones. They are usually laid singly,

but rows of eight or ten are sometimes found. The eggs are scarcely visible to the naked eye and are but a little over one-hundredth of an inch in length. They are elongate, pear-shaped, smooth, shiny and of a light orange color when laid, becoming darker before hatching. A short stalk on the larger end attaches the egg to the bark, and a long thread-like process projects from the smaller end. According to the temperature, the eggs hatch in from eleven days to one month. Immediately after emerging from the egg the larva seeks a suitable feeding-place and is soon at work sucking the sap with its short beak, which appears to rise from between the front legs. The favorite feeding-places are in the axils of the leaf petioles and stems of the forming fruit, and there they gather in close clusters. If very numerous they gather on the under side of the leaves, along the midrib. They move about very little, sometimes becoming quite covered with their own honey-dew. If disturbed they crawl about quite rapidly. The adult appears about one month after hatching from the egg. This adult has quite different habits. The strong legs and wings enable it to spring up and fly away with surprising quickness upon the slightest unnatural jar or the near approach of the hand to its resting-place. They feed upon the juices of the leaves and tender twigs of the trees, and seem to have no favorite feeding-place. These summer forms fly readily from tree to tree, and could easily be borne by winds for long distances, while the hibernating forms are quite sluggish in their movements and are readily captured when found.

Three or four days after their transformation, the adults of the early summer brood copulate, and egg-laying begins for another series. These eggs are usually laid singly, sometimes several in a row or group, not on the twigs, but on the under side of the tenderest leaves, among the hairs near the midrib or on the petioles near the leaf. These eggs, under the warm summer temperature, hatch in from eight to ten days, and the same round of change from the larva to the adult stage is again gone through. After midsummer, this brood, in turn, lays its eggs, and from these eggs hatch the insects which pass through the winter. In New Jersey, I have this year found specimens still in the pupa state, although the majority were already winged, on the 21st day of October, and before the end of the month all the pupæ transformed into adults. These adults do not pair, but seek winter quarters, as already described, and live through

until coaxed out by the warm days of early spring, when they copulate, lay eggs and the life cycle, already described, is entered upon. It will be readily noticed that owing to the number of broods in a single year, the insect has the possibility of increasing at an extremely rapid rate, and that in a comparatively short time an orchard could be completely overrun by them, and they would then be ready to spread in every direction.

The Insect in New Jersey.

The first notice of the occurrence of this insect in our State reached me through Prof. Beckwith, of the Delaware Experiment Station, who found it in one of the large orchards and nurseries near the Delaware river. Personal investigation showed that the insect was moderately adundant in one orchard, and that it infested about all the varieties of pears there grown. Bartletts, Keiffers, Lawrence, Le Conte and several other varieties were about equally attacked, though more specimens were found on those varieties which held their leaves longest. In a closely-adjoining orchard, belonging to the same parties, only a very few specimens were found. From the history of the insect, as I was able to learn it, I think it probable that specimens were introduced on trees obtained from New York State, and that certainly one, and probably two, years have passed since the insect was introduced. There is every reason to believe that it is still confined to this one locality, but there is also very great danger that if the winter of 1893–94 proves to be one favorable to the insects—that is, a moderately hard one—they will begin to spread in spring just as soon as the first brood matures. It behooves the fruit-growers of the section along the Delaware river between Burlington and Camden to keep a close watch for this insect, and to be ready to take active measures immediately upon its discovery.

Remedies.

From the fact that the insect hibernates upon the trees during the winter we have an opportunity to take measures against them during a long period of time. I would recommend that during a mild spell all the rough bark of the trees be scraped off and burnt, and that the trunk and larger branches of the trees be thoroughly washed with a strong

solution of whale-oil soap, say one pound in four gallons of water; this mixture to be applied with a brush so as to get into all crevices and irregularities, and particularly into scars and holes, if any there be, in the tree. On the smaller branches where the bark is smooth and even, the wash need not be applied, for there is little chance of there being any specimens in such localities. In the spring a close watch should be kept upon suspected trees, and if any specimens are noticed on the buds, young leaves or in the places previously mentioned, the trees should be treated to a liberal application of the kerosene emulsion diluted fifteen times. Where an orchard is known to be infested the spraying should be made, even if no insects are noticed, and it should be done before the pear blossoms open and as soon as the leaves are well developed. It is important that this spraying be done while the insects are in the larva state, for the adults fly so readily that very few of them would be reached by the spray. The best time to make the application is soon after a heavy rain. I am inclined to think that our State is a little out of the normal range of this insect, and that if active measures are taken it may be possible to exterminate it entirely. At all events this is another case which proves the importance of a very careful examination of all plants that are imported from other sections of the country, for it is a great deal easier to import pests than it is to get rid of them after they have once obtained a foothold.

The Wheat-Head Army-Worm.

(*Leucania albilinea*, Hbn.)

In the general review, this insect will be found mentioned as one of the unexpected appearances of the season, and in the extracts from the crop bulletins there will be found a very fair statement of the distribution of the insect. As soon as the first complaints were received, I wrote at once to the gentlemen sending the reports, asking them to send me specimens, as well as an account of the extent and character of the injury done. As is usually the case, most of the growers claimed that here was something that had not been previously known to them, and in almost every instance it was stated that the

insects had not been noticed until the grain was nearly ready to ripen.

July 6th, Mr. John W. Lequear, of Frenchtown, sent me a specimen which he "found on the heads of wheat, gnawing into the grain and littering the ground like wheat bran," and his question was, whether or not they were army-worms.

July 7th, Mr. John Quick, of Beverly, wrote that when he first saw them the wheat was in milk, and the milk from the injured grain would run down the stems. He thought they would stop eating when the grain got hard, but, in his opinion, they ate it more in shock than standing; he found them eating in the middle of a sheaf, and he spoke of the ground being covered "as if there had been bran sown over the field."

July 8th, Mr. John Bellis, of Kingwood, wrote that the specimens were first seen about two weeks previously, and that they do not infest any other plants, so far as he knew. He states further that he found them feeding on the grain in the wheat and rye and on the seeds in the timothy. He estimates the damage to each at about three per cent., and finds that they are on the decline. He also spoke of the ground being covered with bran. On that same date Mr. S. B. Ketcham, of Pennington, wrote me that at that time the insects had disappeared, and that they were first noticed on June 23d. Sometimes, he says, there were two on one head, and they usually ate from three to six grains on a head. Some of the ripened grains are only about half eaten. He speaks of their resemblance to the army-worm, and again mentioned the fact that the ground appeared covered with bran. From Mr. J. Blackwell, of Titusville, I received further specimens, with the statement that the insects were nearly all gone.

July 12th, Mr. John Bellis again wrote, stating that his previous estimate of the damage done had been too low, and that from conversation had with the farmers of the vicinity, he concluded that at least five per cent. of the grain was destroyed.

July 17th, Mr. V. R. Matthews, of Ringoes, sent me specimens of the insect. He stated that on making inquiry among farmers, he found a wide difference of opinion as to their number and the injury done to the wheat. In some fields they were much more numerous than in others near by, and in some places none at all were seen. Speaking of one of his own fields, he stated that they appeared to be thickest on the side adjoining a piece of timothy grass, and adds that

they ate nearly the entire heads off the grass along the wheat, after the wheat had been cut.

Subsequent to this date nothing was heard of the insect, and it appears that the first brood only, for some unexplained reason, had taken a notion to attack wheat, rather than to stick to their normal food plants.

Life History.

This insect is by no means a new one, and was fully described by Dr. Riley in 1877, in the ninth report on the insects of Missouri, where also it was figured. At that time Dr. Riley traced back the history of the insect to 1874, when it was injurious in Maryland and Pennsylvania. It was again troublesome in the same States in 1875, and in 1876 it appeared in Kansas, doing considerable damage. The insect is found throughout the entire Eastern United States, extending north into Canada and west to the Rocky mountains, and it is more or less abundant every year, being one of the insects which the entomologist terms "common." Normally its food consists of grasses and the seeds of grasses, and it is only under very exceptional circumstances that they attack cultivated plants, such as wheat and rye. As I have already stated, we are absolutely unable to give any reason for the sudden appearance of this insect in numbers. Their disappearance could be more easily accounted for, because, of all the specimens sent me, more than fifty per cent. were infested by parasites; that is to say, there was an increase of natural enemies corresponding to the increase of the species, and as a result it appears to have been reduced to its normal condition before the end of the season.

The first moths make their appearance in this State during the latter part of May, when eggs are laid, and the bulk of the larvæ become full grown about the time the wheat is in the milk. These larvæ go underground for a short distance, change to a brown chrysalis, and make their appearance as moths late in July or very early in August. They have much the same general habits and structure as the true army-worm, belonging, indeed, to the same genus, and the eggs are also secreted as in that species. The eggs are thrust, in single, double or treble rows, of five to fifty or more in a row, between the sheath and stalk of the grain upon which the larvæ are destined to feed. They are generally fastened slightly to the inside of the sheath

and are readily seen upon pulling this aside. They are thrust in sideways, compactly pressed together and are not covered with any glistening or adhesive fluid. Each egg when examined closely is found to be very soft and yielding, so that its form is fashioned somewhat by the pressure it receives from its neighbors and from the leaf. The shell is corrugate rather than granulate, is a pale yellowish and translucent when first laid, becomes slate color before hatching, and the shell is so extremely delicate that every hair of the embryo may be seen through it. These eggs hatch during the summer in from three to five days from the date of deposition. When first hatched the larva is pale, with a black head and a shiny spot on the top of the first and last joints. It soon becomes green, with a brown head, then striped with five pale and six darker lines, and after going through five and sometimes six molts it assumes the appearance shown in Figure 6. When full grown the best-marked specimens are prettily striped with sulphur yellow and straw yellow, and with light and dark brown. The head is large, straw-colored, with two brown marks from the top to the lower face.

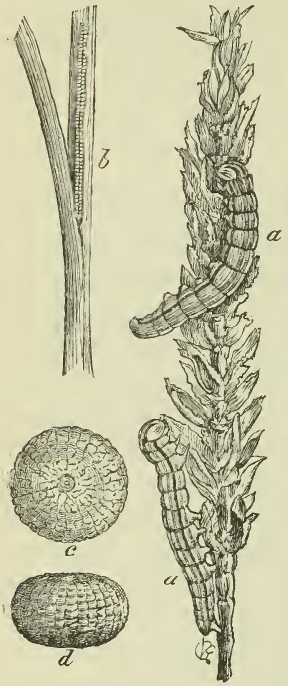


Fig. 6.

Wheat-head army-worm: *a*, *a*, larvæ; *b*, eggs, natural size; *c*, *d*, egg, top and side view, enlarged. (After Riley.)

The habit of feeding upon the grain becomes pronounced only after the larvæ are full grown, and prior to that time they feed upon the leaves and are seldom noticed. The pupa is naturally formed just beneath the surface of the ground, but frequently under weeds or other rubbish. It is of the ordinary mahogany-brown color and terminates in a stout, horny point. The larvæ acquire their full growth in from three to four weeks from hatching, those of the second brood developing somewhat

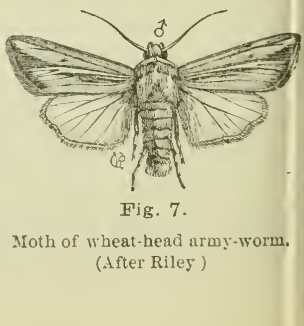


Fig. 7.

Moth of wheat-head army-worm. (After Riley)

more slowly than those of the first. The pupa state in the summer brood lasts from ten to fifteen days. Those formed in the fall remain underground during the winter and these are usually found deeper under the surface, say from four to six inches.

The parent moth, shown in Figure 7, has the front wings straw color, with a white line running along the middle to the outer third, and shaded with brown and purplish brown, as shown in the picture.

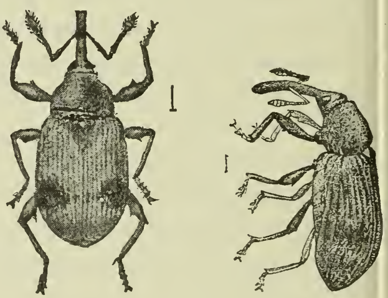
Remedies.

I have already stated that of the insects sent me, by far the greater proportion proved to be infested by parasites, mostly one of the Tachina flies, which had destroyed more than one-half of all those received. This indicates that under normal conditions the natural enemies of the insect serve to keep it in check, and that only abnormal conditions enable it to escape and increase in an undue manner. We are justified from the past history of the insect in believing that, most probably, next year will not see a recurrence of the same increase. But it is also well to adopt whatever measures may seem beneficial whenever it is possible to do so. During the winter the insects are in the pupa state, underground, and there they remain until well along in spring. Plowing the ground infested by them to the depth of six inches, at any time after the middle of September, will probably result in the destruction of by far the largest percentage of the specimens, while plowing the ground as early as possible in the spring will result in the destruction of a considerable proportion, at least, though this is not nearly so efficient as fall or winter plowing. After the insects are once hatched and have invaded a wheat-field, there is nothing to be done except cut the wheat just as soon as it is safe to do so and thresh it at once in order to stop the injury. If the winter of 1893–94 proves moderately mild, there is little probability that we will see any re-appearance of this species in 1894 in injurious numbers.

The Strawberry Weevil.

(*Anthonomus signatus*, Say.)

This insect has been reported as injurious from several localities in the southern part of the State, and mainly from Cumberland county. As yet it has not caused any serious amount of trouble, but if it keeps on increasing in number as it has done in States to the south of us, it may become troublesome in the near future. Heretofore the strawberry has been one of the few fruits that have been very little troubled by insect attack in our State, and there is no crop that will show damage from the money side more rapidly than this. The insect is a small weevil or snout beetle, belonging in the same general family with the "plum curculio," and is, in the main, black in color, marked on the wing-covers with whitish, hairy clothing, and with a somewhat variable amount of dull red. The injury done by the insect is what is generally known as a blasting of the buds; that is to say, the buds will die, shrivel up, and the blossom does not appear, or in some cases the flower will open but no berry will set. The bloom has been blasted, but what has caused the "blast" is generally not known to the farmer, unless the insects have appeared in numbers sufficient to attract his attention. By means of their beak the insects eat into the bud before it has opened, making a very small, round hole, and in this the insect lays its egg. After the egg has been laid, the insect eats into the flower stem, a short distance below the bud, puncturing it in such a way as to cause the bud to droop, turn brown and die, and afterwards, in most cases, to drop to the ground. The buds are not severed outright, as a rule, but remain for a longer or shorter time on the vines before falling. Sometimes, especially towards the end of the season, these flower-stems are punctured and killed, even when no eggs are laid in the buds. In the little bud the egg hatches, a small fleshy larva develops, and this



a *b*

Fig. 8.

Adult beetle: *a*, from above (after "Insect Life"); *b*, from side (after Riley).

in a short time changes to a beetle. The object attained by the puncture of this flower-stem is twofold. First, the development of the bud is arrested, the outer envelope turns hard and dry, and remains folded, thus retaining the pollen and the eggs or growing larvæ of the insect. The second result is obtained when the buds drop to the ground, where they are kept more or less moist. If allowed to remain on the stem in ordinary dry weather, the injured buds would have eventually become so dry as to prevent the development of the insect within. Buds are attacked quite early in the season, in April and May, and the larvæ hatch only a short time thereafter. Mature beetles begin to issue during the early part of June, and by the end of the month all or nearly all will have developed. Soon after they become matured the beetles disappear and go into winter quarters; that is, seek shelter and hiding-places where they can remain until next spring again brings them forth to commence their destructive work. Occasionally, specimens will be found throughout the season, but these are exceptions, and we have no reason to believe that any breeding is done after the first brood matures. The strawberry is by no means the only food plant of this insect; but blackberries, raspberries, blueberries and huckleberries, and probably quite a number of other plants, are attacked. The food of the beetle is, in large part, the pollen of the buds which it punctures, and the larva itself also feeds largely, if not exclusively, upon pollen, and therefore those varieties of strawberries which, like the Sharpless, produce an abundance of pollen are the most likely to be attacked. The insect has been long known to collectors, and appears in considerable numbers each year. As a strawberry pest, it was not so well known until comparatively recent years. Some ten years ago, I met with it on Staten Island, N. Y., to which point I was sent to investigate the history of the insect by Dr. Riley, on behalf of the United States Department of Agriculture. At that time the insect did considerable damage in a few isolated localities only, and had become more

Fig. 9.

Anthonomus signatus: Spray of strawberry, showing beetles at work—natural size. (After Riley)

troublesome during a period of two years. The year following, as I understand, it did comparatively little injury, and since that time there has not been any serious complaint from that point. For a year or two last past, complaints have been received from Maryland, Delaware and Virginia, and the insect has been studied by Prof.

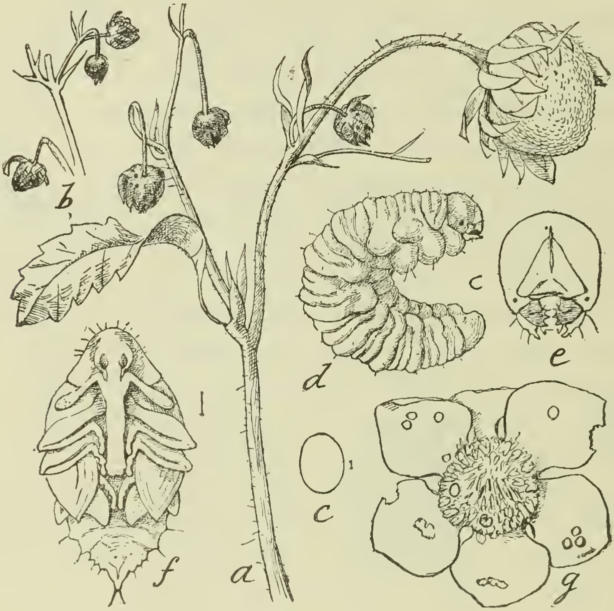


Fig. 10.

Anthonomus signatus: *a*, *b*, strawberry spray, showing work in bud and stem—natural size; *c*, outline of egg; *d*, larva; *e*, head of larva—much enlarged; *f*, pupa; *g*, open bud, showing location of egg on left and punctures made by snout of beetle on petals (From "Insect Life.")

Beckwith, of the Delaware Station, and by the United States Entomologist. In "Insect Life," Vol. 5, No. 3, is a full account of the insect, by Mr. F. H. Chittenden, one of Dr. Riley's assistants, from which the main points of the preceding life history have been taken. From what has been observed in these States, we have reason to fear that the insect will become increasingly troublesome in New Jersey for a year or two to come, particularly in those counties in which it is now found. No real damage was done during the season of 1893; but if the same favorable conditions for its development continue, serious trouble may be looked for in 1894.

Remedies.

From what has been said of the life history of the species it is obvious that the insect is one that is difficult to reach. There is no period at which we can hope to destroy it by means of poisons acting through the stomach. The insect eats so little of the plant itself that there would be no reasonable chance of its getting a poisonous quantity of even arsenic, were it applied as strong as it would be possible for the plants to bear. Contact poisons offer very little promise of relief. The beetles are so well protected by their outer covering that none of our insecticides will penetrate these, and their breathing-pores or spiracles are also so well protected that such substances as pyrethrum could hardly offer much chance of success. The only proceeding that has been found reasonably satisfactory is covering the strawberry beds by means of newspapers or more elaborate screens of linen or cloth of some kind. Varieties other than those that produce pollen of course need no protection; but the difficulty is that it would be necessary to have uncovered pollen-producing varieties to fertilize the others, and it would be necessary then to protect the plants until the flowers were fully opened and the pollen developed. Before the insect could injure these open blossoms, even if it attempted to do so, the work of fertilization would probably be accomplished, and by reducing the number of pollen-producing plants to a minimum the work of protecting them would be correspondingly reduced.

Farmers are advised to keep a close lookout for this insect during the season of 1894, and to notify the Entomologist of its appearance promptly.

The Corn-Root Webworms.

(*Crambus*, sp.)

Complaints of injury to corn roots by a "webworm" have become increasingly abundant for two years past in New Jersey, and were never so great as during the season of 1893. In some localities, corn was replanted two or three times before a stand was obtained, and even then the fields were frequently ragged and irregular. In other districts, the insects seemed to be entirely unknown. As a rule, the most severe injury is done early in the season, and by persistent

replanting, as soon as injury to the hills is noticed, a stand is obtained; but sometimes the insects continue on and injure corn even when a good start has been made. On June 28th, I found an infested field near Bridgeton, in which corn was well advanced and which was badly injured. The first apparent trouble is a stoppage of growth in the plant; then it becomes deformed and frequently dies. If it is a vigorous one, it sometimes makes a new start, but remains far behind the other plants which have not been infested. The field in question and others in the vicinity had been replanted twice and, in part, three times, and I found many hills from which I took anywhere from two to six larvæ, lying in a loose web among the soil and close to the roots. They had, in each case, eaten into the stem, and in one case had actually bored into its center for a short distance. Reports of injury have come in quite sparsely, and most of my information was obtained by conversation with the farmers. The accounts given differed quite considerably, and the conclusion was forced upon me that more than one species is concerned in the injury. This is not surprising when we consider that the corn-feeding habit is not a primary one and has been, apparently, acquired within a comparatively few years, not in our State only, but in other parts of the country. Accounts of root webworms have been published in New York, Delaware, Iowa, Ohio, Illinois, Indiana and other States, and in nearly all of them injury is increasing annually.

Habits of the Insects.

Walking through grass-lands at almost any time during the summer, we note, flying up before and on all sides of us, white or yellowish moths, which soon alight again and hide in the herbage. If we approach carefully and find the location of a specimen so we can observe it, we will note that the wings are closely rolled around the sides of the body, and that it has a quite long, projecting beak or snout, which further examination shows are the palpi or mouth feelers. This peculiarity gives the insects the common name of "snout moths," and they belong to the genus *Crambus*. They are also quite frequently seen on fences inclosing the fields, and I well remember an occasion many years ago, in Illinois, when I found dozens of specimens in this way of a species I had not previously seen. If we capture a number of the specimens started up from the

fields and examine them more closely, we will find that several species are represented, and that many of them are marked and ornamented with silver stripes and bands, and frequently also with golden lines or scales, giving the insects a positively beautiful appearance. From the situations in which they are found, the insects have also been termed "grass moths," and we will find a somewhat different set of species at different seasons of the year. Being thus, primarily, grass-inhabiting insects, it is not surprising that the injury is largely confined to fields in corn after grass.

Life History.

The life history of all the species is approximately similar. The moths make their appearance in spring, varying somewhat according to weather and temperature, but usually near the middle or latter part

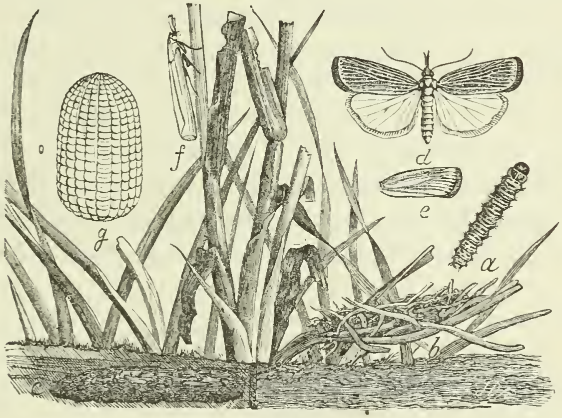


Fig. 11.

Crambus vulvivagellus: *a*, larva; *b*, web of same; *c*, cocoon; *d*, moth, wings expanded; *e*, variety of fore wing; *f*, moth, wings closed; *g*, egg, much enlarged. (After Riley.)

of May, and the eggs are laid in grass-lands at about this time, or early in June. From studies made by others, it is probable that about 200 eggs are laid by a single female, and that they are dropped among the rubbish and vegetation on the surface or are very loosely attached to the blades or stems of grass. The eggs are yellowish in color, oval in form and are beautifully ribbed and sculptured, as shown in the figure. The larvæ hatch from these eggs in from 6 to 10 days, and they at once commence feeding on the grass and very

soon thereafter form a loose web or tube of silk—sometimes on the surface, sometimes a little below it. In the latter case they run nearly straight burrows among the roots or above them, and the feeding is done on the stalk or outer leaves, or in rare instances the crown is attacked and the plant killed. Grass will, however, support a very great number of insects without showing any apparently serious injury, and few farmers realize how great an annual loss they suffer from this source alone. The species differ quite considerably in the character and completeness of the webs or tubes made by them. Sometimes the tube is complete and quite firm, sometimes it is loose and very imperfect, and sometimes there is no apparent web at all. The larvæ vary from white or yellowish to pink or reddish or to brownish, according to age or species, and they are furnished with minute tubercles set with little tufts of bristly hair. The larva matures in from 5 to 7 weeks, forms a cocoon in the soil, sometimes at the end of its larval tube, and in from 12 to 15 days the moths issue—say early in August and probably throughout that month. Eggs are laid in August and September, again in grass-lands, and the young larva hatches in September or October, attaining its growth in part during that same year. When overtaken by winter it is half grown or more, and hibernates just below the surface in its silken tube, ready to recommence feeding in spring. As soon as the grass starts the larva also begins feeding, reaching maturity early in May or thereabouts, and thus completing the life cycle of one entire year.

Injury on Corn.

It is quite the usual practice to follow sod by corn, not only in our State but elsewhere, and, as a matter of course, whatever insects may have been in sod remain to attack corn. If the plowing is left until well along in spring there is a fair chance that the moths from the hibernated larvæ will have matured and deposited eggs, leaving an infested ground for the corn. After the corn is up and the young larvæ have hatched they of course attack whatever food plant they find, and the corn is near enough to grass to induce them to feed upon and relish it. The young larvæ construct a web, half an inch to an inch below the surface of the ground, usually winding it irregularly among the roots and stalks of corn. Hills infested by these caterpillars have the stalks when small cut off entirely or in part, the

upper portion being frequently devoured. Larger stalks have cavities gouged out of the sides at the surface of the ground or a little above, and sometimes channels are eaten to or even in the center. The leaves also are eaten at the base, and numerous holes are scattered over the blade, sometimes with peculiar regularity, arranged in transverse rows of three to five, the rows about the length of the larva apart. Often the stalks when injured as above described decay and rot off.

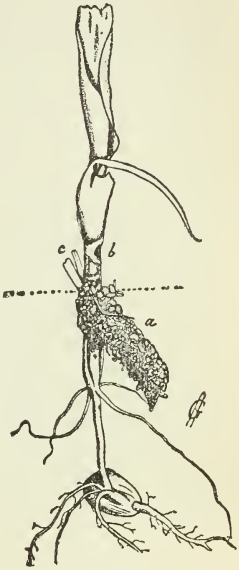


Fig. 12.
Young corn plant attacked by root webworm: *a*, web of larva; *b*, cavity eaten in stalk; *c*, leaves cut off. (After Forbes.)

Mr. John W. Lequear, of Frenchtown, N. J., sent me an account of the larvæ cutting corn in his vicinity, and besides the species making the distinct web, sent me also specimens of an allied larva and "some stalks of injured corn. You will see they bore or eat holes in the stalk of corn just above its union with the root. If we scratch in these hills, we find these worms in the holes or mixed in the loose dirt, without appearance of web." The larva sent me is darker than the web-makers, but is evidently a close ally, and probably belongs to the same genus. After the summer brood of moths issue, no eggs are laid in corn-fields, but grass-lands are sought by them for purposes of oviposition.

Remedies.

These larvæ rarely occur in corn except where it is planted on sod, and hence injury could be avoided by planting some other crop between sod and corn. If this is considered undesirable, a considerable advantage can be gained by care in fixing the date of plowing. If fall plowing of the sod is feasible, this should be done early, so as either to prevent egg-laying or to starve out the larvæ already hatched, or it may be done very late, exposing the larvæ to the weather or burying deeply. If fall plowing is undesirable for any reason, plowing should be done early in spring and the ground should be left clear for two weeks, if possible. No moth will lay its eggs on

bare ground, and if the plowing is done before eggs are laid in the sod, I should expect the corn-field to remain clear of pests. The later plowing is done, the more danger of injury. In the southern and middle counties plowing should be done not later than the first week in May, and earlier if possible. In the more northern counties, a week or two weeks later may answer the purpose.

Direct application of insecticides is not feasible as against these insects; but a very great advantage is everywhere found in favor of those using the mineral fertilizers. In adjoining farms treated exactly the same as far as cultivation is concerned, the one on which the mineral fertilizers were used was free from injury, while the other was badly infested. I would very strongly advise the application of all the necessary potash in the form of kainit, put on as a top-dressing after the field is prepared for planting, and I would expect to find good results from this practice. Fall plowing and kainit as a top-dressing in spring, will, I feel convinced, destroy by all odds the greatest proportion of the webworms that may infest the sod, and would also destroy or lessen many other pests which trouble corn during the early part of its life.

The Pale-Striped Flea-Beetle.

(*Systena blanda*, Mels.)

Flea-beetles are gradually coming to the fore as pests of the first rank, some, like those infesting round and sweet potatoes, being the most troublesome on crops infested by them. For some years past one of the larger species, measuring nearly one-fourth of an inch in length, varying from yellow to black in color and with a white or yellow stripe on each wing-cover, has been becoming continuously more common. Four or five years ago I found it injuring beans in the northern part of the State, near Washington, and I have found it since from that point to Cape May, on a very great variety of plants. In several of the Central and Western States it has appeared in numbers sufficiently great to attract attention, and Prof. Bruner, of Nebraska, considers it one of the more troublesome forms on sugar-beets.

During the summer of 1893 this species was more abundant than ever, particularly in the southern and central counties, and it was most destructive to carrots near Bridgeton, where I had an opportunity of studying the species, June 26th, and where it had almost entirely destroyed every field of carrots. There was a severe drought under way at that time and the plants were backward; but as soon as they appeared above the surface they were attacked and forthwith eaten off. The leaves of young beets were also infested, from two to ten specimens being present on every plant; but they were more vigorous, with larger leaves, and better able to sustain the injury, no permanent damage being done. Melons of all kinds were also attacked, and in one field of cantaloupes the injury done by these creatures exceeded the injury done by the striped beetles. The beetles were not, however, confined to cultivated plants, but attacked weeds as well; purslane was universally infested, and the pig-weeds showed not a sound leaf, many of them being even killed. Corn was somewhat infested, but no real damage was done, because the comparatively small holes eaten in the blades of a vigorous corn plant could not check growth to any appreciable extent. In some of the Mississippi States the injury to corn is more marked.

Fig. 13.

The pale-striped flea-beetle, *Systena blanda*. (From Bruner.)

Life History.

Very little has been published concerning the early stages of this insect, and that is comprised in a statement made by Prof. Forbes, of Illinois, that he bred the beetle from a slender white larva feeding on sprouting corn. I am informed that since this was published, in 1886, Prof. Forbes has succeeded in working out the full life cycle of the insect, and that it will be published in the near future. It is certain, however, that in this State at least the larva feeds on something other than sprouting corn, for not the entire corn-planting of

South Jersey could support the enormous number of beetles that appeared in June, 1893, in Cumberland county alone.

Remedies.

Owing to our incomplete knowledge of the life history of this insect, remedial measures to be taken can be only suggestive, and may not be the best when we have more information on the subject. The beetle feeds exposed on the leaves, however, and is mandibulate, chewing its food; hence the arsenical poisons are indicated and will undoubtedly be effective. This is one of those instances when a knapsack pump with an underspray nozzle, such as is herewith illustrated, is essential, and with it a large field can be rapidly and

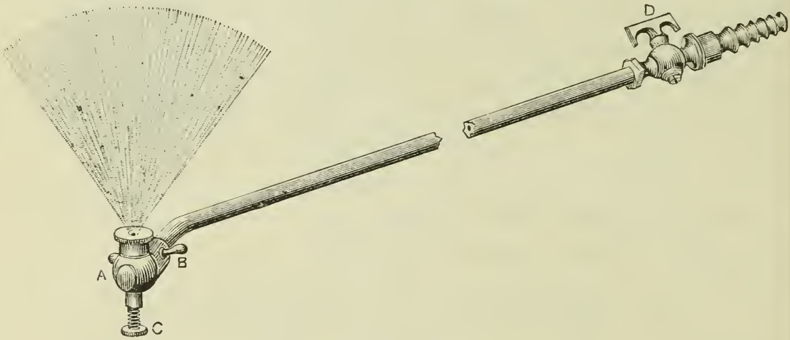


Fig. 14.

Undersprayer: *a*, nozzle; *b*, union joint, to hold the nozzle in any desired position; *c*, degorger, for clearing nozzle; *d*, shut-off. The lance is three feet in length.

thoroughly covered.* Paris green or London purple with lime, in the proportion of 1 pound in 175 gallons of water, would be sufficient. The spraying should be done as soon as the beetles are first noticed, and the weedy plants, such as purslane and pig-weed, should be as thoroughly sprayed as the crop itself.

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*This lance and nozzle is made by Wm. Boekel & Co., 518 Vine St., Phila, Pa.

The Chestnut-Weevils.

(*Balaninus*, sp.)

Chestnuts, as a crop, are not grown to any very large extent in our State; yet, there are some tracts of considerable size from which a very good profit is derived in favorable seasons. Of late years, efforts have been made by a few of our leading nurserymen to introduce some of the large varieties, such as the Spanish and Japanese,

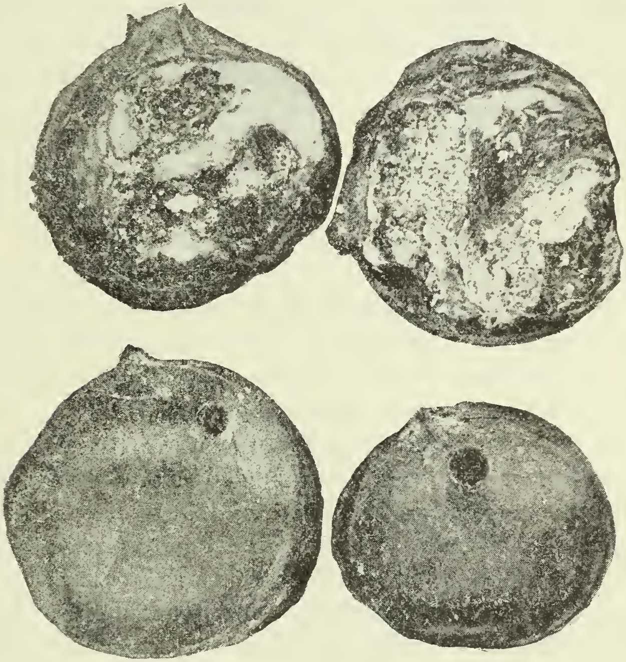


Fig. 15.

Chestnuts injured by larva of *Balaninus*. The upper figures show the nuts with the shell removed and the cavities made by the larvæ; the lower figures show the holes from which the larvæ emerged. About one-fifth larger than natural size. (From a photograph.)

and with very good success. It has also been planned to set out a large acreage of our American varieties in the western and southern parts of the State, on land which has naturally grown this nut. The only drawback to chestnut culture is the fact that many of them get "wormy," but up to the present year the percentage of attack on the imported trees has been small and scarcely noticed. The crop of

1893, however, was almost completely destroyed, and in the nurseries of Parry Brothers the ground was covered with huge nuts of some of their improved varieties, among which it was almost impossible to find a sound specimen. The native, uncultivated nuts were as badly infested, and in the market nearly half of the nuts proved wormy, the number of round holes visible in the shells at even a casual glance showing the extent of the injury. The increase among the insects seems to have been general, therefore, due to some favorable climatic cause, and in such circumstances little selection of varieties was made by the insects: nearly all suffered equally. According to the Messrs. Parry, the Paragon (Spanish) and Hannum (Spanish) were least attacked and nearly free from injury, while there was little choice among the others, whether native, Spanish or Japanese.

The larva causing the injury is a soft, white, footless grub, with a yellowish head, and it eats large, irregular cavities in the meat of the nut, becoming full grown when the nuts are ripe and drop, and issuing out of a round hole which it cuts through the shell.

The beetles produced from these grubs are yellowish, oval in outline, with an extremely long and slender black beak, and there are at least two species, *B. proboscoideus* and *B. rectus*, which attack the chestnuts in our State. It is of no essential importance to the farmer to be able to distinguish these species, since their habits are practically alike. Both of them make their appearance during the time the chestnuts are in blossom, say from about the middle of June to the middle of July, although occasional specimens are found later in the season. At the time of blossoming the chestnuts are fully formed, and larger than might be supposed. The envelope or burr is over three-quarters of an inch in height, soft and covered with distinct tubercles from which the prickles afterward develop. It is at this time that the eggs are deposited in the embryo nut, and to enable the insect to reach this point, the enormously long, slender beak is brought into play. This beak or proboscis is from one-half to three-quarters of an inch in length, and by its means a small hole is bored into the burr. Through this hole the egg is worked into place in the young nut. The small puncture made by the slender beak of the insect heals completely, so it becomes impossible afterward, when the nuts are ripe, to discover how the larvæ entered them. As soon as the larvæ are full-fed they leave the nut, and this may be at any time between the middle of September and the first of November. Usually a single larva is found in our

American species, but occasionally a large nut may contain two. In the large varieties, like the Spanish and Japanese, I have found as many as six, and in most cases more than one. After leaving the nut the larvæ make their way a short distance underground, and remain there unchanged until the following spring, changing to a pupa from three to six weeks before the imago is ready to emerge. Dr. John Hamilton, of Alleghany, Pa., who has studied these species and from whose papers the above account is derived, states that a considerable number of the larvæ do not develop the first year ensuing upon their full growth, but lie over until the second year, and this is nature's provision for the continuance of the species should there be an entire failure of the crop in any one year, as sometimes happens.

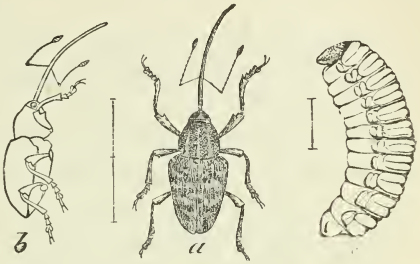


Fig. 16.

Chestnut-weevil, *Balaninus rectus*: *a*, from above; *b*, outline from side (after Riley); *c*, larva (after Packard.)

Remedies.

The life history given above shows at once that there is no period in the development of the insect when it is within reach of poisons, either those that act by contact or those that are eaten. The egg is placed safely out of reach, and the larva feeds, snugly housed, absolutely beyond danger from any application that can be made. The beetle feeds very little, and we cannot possibly cover the forming burrs with any poison that would be repellant or destructive. On small trees a great measure of protection could undoubtedly be obtained by jarring the beetles into an umbrella or on a sheet, and this would have to be done every day during the period of blossoming. In a nursery it might be feasible; but certainly not on a large scale or with large trees. After the larvæ leave the nut and go underground they are exposed to many natural enemies in the form of insectivorous animals and predaceous insects, and their numbers are materially lessened in this way. In nurseries, or where the ground is cultivated, most of them are killed by the ordinary farm practice and particularly where

the mineral fertilizers are applied; but this again would not be serviceable in extensive groves which are not cultivated. There is really only one process that offers a good chance of success, but this would prove effectual, I believe:

First. Get rid of all wild trees in the immediate vicinity which might serve to propagate the species.

Second. Plant in the groves a majority of those varieties which experience has shown are least affected when the beetles are abundant. These varieties, according to Parry Brothers, are, in their experience, Paragon and Hannum, but they may be different elsewhere, and other varieties may be even more exempt.

Third. Plant also a fair number of the varieties which experience has shown are worst infested when the insects are not common, and which may be considered favorites, and these trees should be pretty evenly scattered in the grove.

Fourth. Just as soon as the nuts begin to drop, see that everything under the favorite trees is gathered immediately, and at once ship or destroy the nuts. The object is, of course, to get the nuts before the larvæ leave them, and thus prevent them from completing their changes. An essential element in the success in this proceeding is promptness and thoroughness in gathering the nuts, as larvæ are leaving them constantly. Indeed, good farming for nut culture demands that the crop be gathered just as soon as it is in any way possible.

By planting trees that are favorite objects of attack by the insects, we attract them to definite or known points, and by keeping the ground under these trees tolerably clean, so the nuts when they drop can be readily seen, the crop from these trees when gathered will be found to contain much the greatest percentage of the larvæ to be found in the grove, and these trees will protect the others. I would advise 10 per cent. of the trees in a grove to be of varieties most subject to attack.

Systematic early gathering of the nuts will in itself appreciably lessen the number of weevils for future years. It almost goes without saying that wormy nuts should not be thrown outdoors, but should be *burnt.* If nuts cannot be sent to market at once, they should be put into tight boxes or barrels, not necessarily covered,

through which the larvæ cannot make their way. When the nuts are removed, the accumulation of larvæ should be destroyed with boiling water, or in any other convenient way; but never thrown outdoors, where they might get opportunity of getting underground to complete their transformations.

Beneficial Insects.

The subject of beneficial insects is, in some respects, quite as important to the farmer as that dealing with the injurious forms. As a matter of fact, the number of species that are economically important on account of the damage they do to our cultivated crops is comparatively small. There are not more than a few hundred species known as really injurious in field and orchard of the over three hundred and fifty thousand described, while the actual number of species of insects has been estimated at two millions. In the first place, only species that feed upon vegetation are apt to be troublesome to the farmer, if we except the few that are parasites upon domestic animals and birds. The whole of that exceedingly large series of insects that is predaceous, feeding upon other species and upon a variety of lower forms of animal life, is certainly not injurious, even if not always actively beneficial. All that great number of forms feeding upon all kinds of decaying vegetable and animal matter is actively beneficial, removing or changing into plant-food the forms of organic matter that might otherwise taint the air we breathe and possibly produce epidemic disease. All that immense series with parasitic habits may be counted among those that are directly or indirectly beneficial. Most of those feeding upon honey and pollen of plants are at least innoxious. The considerable number that is aquatic, and lives in one or all stages in or on the water, does no damage to the husbandman. Only those few species, comparatively speaking, that feed upon our cultivated plants, can be considered as injurious in any sense, and of those only an exceedingly small number multiply to such a degree as to require active measures on the part of the farmer to keep them in subjection. Under ordinary conditions, nature has so arranged matters that no one organized creature shall

increase unduly at the expense of any other. Plant life and animal life are correlated in such a way that both may live, within limits that have been gradually fixed. The insect enemies of a plant are never abundant enough to exterminate it, nor are the parasites of those species that feed on plants numerous enough to exterminate them. Everything has gradually reached a point where matters balance, and so they remain, year after year, with comparatively slight variations, climatic changes causing differences occasionally, which are again balanced after a year or two, either by contrary weather conditions, by disease, or by other natural causes. According to this natural arrangement, some insects are always plentiful, year after year, and their enemies, such as they are, never reduce them below a certain point which nature seems to have fixed as the proper one.

One of the important factors that prevents the undue increase of insects feeding upon plant life, is the amount of difficulty that the insects find in securing food for themselves, or their larvæ. Insects feeding upon a plant that is not common, necessarily cannot themselves become common, and undue increase is checked by the mere fact that there is not food enough to encourage it. The female must search to find a place to lay her eggs, and if, as sometimes happens, half a dozen females find the same plant, and all lay their eggs upon it, the larvæ, when hatched, may find themselves too numerous for the amount of food, and will either devour each other, or having eaten the plant completely, will starve to death. Only in those cases where not more than a small number of eggs have been placed upon a single plant, will the larvæ come to maturity. Insects kept in check in this wise, usually have few or no parasites; because parasites for such creatures might result in extermination. Should we now make use of the plant that is ordinarily rare, cultivate it, and instead of having individuals scattered about here and there, sometimes long distances apart, produce great masses of this vegetation, we must expect that the insects feeding upon it will increase in proportionate numbers. The females will not need to search about for plants upon which to lay their eggs; they will find them ready at hand, and can get rid of their entire stock to the best advantage and without the least exertion. Should more than one specimen oviposit upon one plant, the larvæ have the power of crawling to another, and there would be little danger of starvation. Having no active

parasites, or perhaps only a few, the insects would almost certainly become economically important and pests to the farmer. Exactly this has happened in the case of the Colorado potato-beetle, which is one of the most troublesome species that we have to deal with. This has so few natural enemies; that so far as the farmer is concerned, they are entirely unimportant. The insects feeding upon cranberries afford another illustration. Under normal circumstances they have rather a hard task to maintain themselves, while under the artificial conditions introduced by man they flourish and multiply exceedingly. It is, therefore, in many cases a direct result of man's interference with the balance established by nature when we find an abnormal increase of certain species of insects. In other cases, where plants are abundant, insects feeding upon them have a greater number of natural enemies; but the relation of the enemies and parasites to the hosts upon which they feed seems to be, after all, comparatively a fixed one, while the relative abundance of the injurious forms to food plants will be maintained year after year with only unimportant changes. If this food-plant happens to be one that is cultivated, the amount ot injury caused by insects will be approximately the same annually, in many cases making it an unprofitable one to grow, unless the cultivator himself takes a hand in the matter. Such insects are the codling moth, the plum curculio, and cutworms of various species; all of which are extensively parasitized and preyed upon by other insects, but all of which are annually abundant enough to cause a very great amount of injury to the farmer. Nature makes no effort to produce perfect fruit; it confines itself to the attempt to continue the species—that is, to produce seed—and insects that do not interfere with this aim are not injurious in a natural sense, however much they may be so from the standpoint of the agriculturist. There are other kinds of cases where man's interference disturbs the ordinary balance between plant life and insect life, as for example those instances of insects imported from other countries. It is comparatively rare that with an injurious insect we import, also, all or even any of its parasites: this gives the imported forms a very decided advantage among the new surroundings, and while they may in their native home be kept in subjection naturally, in the new country they may become seriously destructive. A very marked instance of this character is the case of the cottony cushion scale, *Icerya purchasi*. This creature

was introduced into California some years ago, without its natural enemies, and speedily became so abundant as to threaten the absolute extermination of the *Citrus* industry. One of the most brilliant experiments, so far as results are concerned, was made upon this insect by Dr. C. V. Riley, the United States Entomologist. By studying it through his agents in its native home, discovering the species that kept it in subjection there and by introducing the principal destructive agent, which was found to be a lady-bird, into this country, the insect has been reduced to the unimportant creature which it is in its fatherland, and has been all but exterminated. This is an exceptional case, and it will not do to argue from the result in this instance that we can treat other insects in a similar manner. Under ordinary conditions parasites or predaceous insects simply check *undue* increase, and this *undue* increase means what nature considers such and not what the farmer may deem the case. It means an undue increase in relation to the number of plants; and what might be a very proper number so far as natural conditions are concerned, would be in the consideration of the farmer an altogether undue quantity and a destructive invasion. It follows, from what I have said, that where nature has so regulated matters that certain insects appear in almost equal numbers each year, we cannot expect to derive any actual benefit from the presence of parasites or predaceous insects.

There is another very important matter to be considered. In the relation of insects to each other, the point looked to is only to prevent the reproduction of more than a definite proportion from year to year; but actual destruction may not be accomplished until the insects are ready to reproduce. For instance, fifty per cent. of the cutworms found in a field early in the season may prove to be infested by parasites, and none of the specimens so infested will ever change to moths that will reproduce their kind. Half of the entire brood has been practically destroyed, and sometimes even a much larger proportion; but—and the "but" deserves to be spelled with capitals—these cutworms will not be destroyed until they have reached their full growth and have done all the damage to the farmer that they could have done had they not been parasitized at all. In other words, the fact that fifty per cent. cutworms in his field are infested by parasites does not help the farmer in the least. Another case: plant lice sometimes begin to increase rapidly in the early part of the season, and soon become so numerous as to be exceedingly

destructive; they are preyed upon by lady-birds and their larvæ, and these will eventually get the better of the plant lice. By the end of the season they will have conquered them, and so reduce their number that next year there will be only a few to start with, just as there were the year before. But in the case of many crops, this does not benefit the farmer in the least, because, before the lady-birds obtain control of the plant lice, the injury to the crop has been done, and although nature has actually preserved its balance, and next year there will be no more lice than this, yet it has been without any advantage to the farmer. Insect diseases stand on very much the same grounds; but these we need not discuss at the present time.

All this is intended to introduce and explain the statement that under ordinary conditions neither parasites nor predaceous insects advantage the farmer in the least, and he must not depend upon what nature will do for him, because nature is in no sense a friend of the farmer more than it is a friend of every other living creature. I am aware that there has been a very great deal said of the importance of parasites and predaceous insects in keeping in check injurious forms, and I would not be understood as depreciating their value in the least; all that I intend is to caution against an exaggerated belief in the efficiency of these natural agents to the exclusion of active efforts by the farmer himself. I do not mean to suggest that we cannot, perhaps, in the course of time, find a way of artificially increasing or of propagating predaceous or parasitic species; but what I mean to assert is, that under natural conditions, and without help by man, injurious insects will not be essentially reduced in number. It is, however, of very great importance that the farmer should be able to distinguish between those insects that are injurious and those that are beneficial, in the sense that they feed upon other insects, because there is no doubt that if, indiscriminately, destructive and beneficial insects are destroyed, the injurious insects in the end obtain an advantage. A farmer should also know how to distinguish friend from foe, for in too many cases

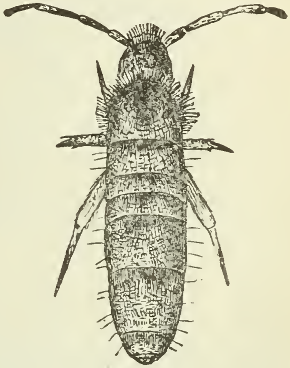


Fig. 17.

Spring-tail, *Lepidocyrtus gibbulus*. (From Standard Nat. Hist.)

insects are charged with injuries which they have never done, and which they could not do, while the real author has escaped discovery.

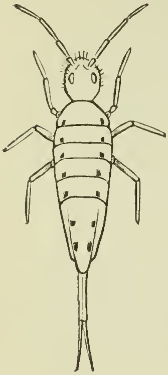


Fig. 18.
Spring-tail, *Degeeria* sp.
(After Packard)

It is intended in the following pages to give a very brief outline of how some of the leading insects that may be classed as beneficial may be distinguished:

In the first place, nearly all the orders contain beneficial insects, and all of the orders ought therefore to be recognized by the farmer. This is not so difficult as it may seem at first sight, because with a very little practice it is easy to tell just where an insect belongs, and, in a general way, what its habits are. According to the Linnæan classification, insects are divided into eight orders, and this classification is a convenient one for our purpose, though it has been greatly modified by recent students.

The first of these orders is the *Thysanura*—"spring-tails" and "fish moths." The members of this order are wingless insects which undergo no transformations, the larval form being retained by the adult. The mouth parts are withdrawn into the head, only their tips being visible, and they are fitted for biting and chewing soft substances. Most of the species are small insects that live in damp places, on the surface of the ground or under the bark of trees, and sometimes they will be found in enormous numbers on the surface of the soil in hot-beds, while on the other hand the

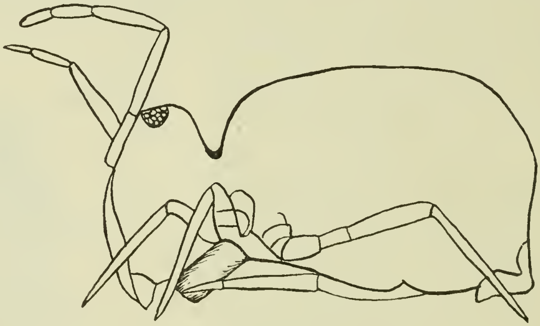


Fig. 19.
Papirius: *a*, spring; *b*, sucker.

well-known fish moth, that is frequently found in houses, lives in warm, dry places, and will serve to illustrate the largest of our forms. The order contains no beneficial insects nor, on the other hand, any that are actively injurious. Many of them have a curious spring-like appendage attached to the tail which is bent under the body, and by means of which the insects are enabled to make leaps that are enormous compared with their small size. Others have long, jointed filaments at the end of the body, which serve no purpose that we know anything about. The insects are rarely seen on plants, but where an overflow occurs millions of them are sometimes found on the surface of the water, on which they hop about as easily as on land. Certain others are sometimes found on the surface of snow, in mid-winter. The species live on dead or decaying vegetable substances and upon fungi, and in turn furnish food for a great many kinds of predaceous forms.

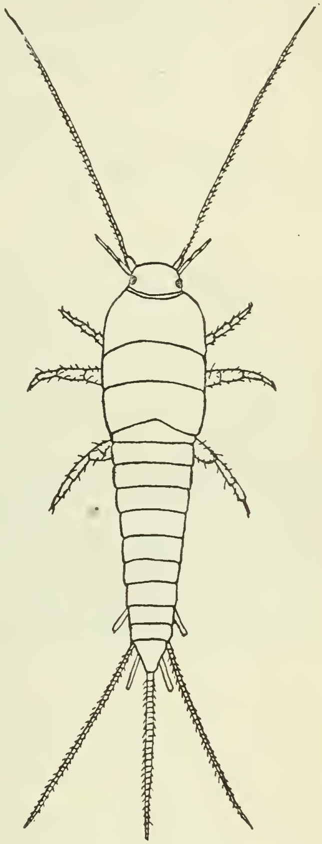


Fig. 20.

Fish moth, *Lepisma saccharina*. (After Packard.)

The second order is the *Neuroptera*. This has been divided into several distinct orders; but for our present purpose we need pay no attention to these divisions, however well founded they really are. All of the insects of this order, in the adult stage, are characterized by having four wings, which are generally in whole or in part transparent and of the same texture, and are divided and crossed by a very large number of veins, which explains the name given them, the term *Neuroptera* signifying "nerved wings." Among the *Neuroptera*, we have a very large number of forms that live during the larval stage under the surface of the water, and spend only their adult life as aërial insects. Among the most prominent forms belonging to this

order are the dragon-flies, forming the family *Libellulidæ*, or the order *Odonata* of recent students. These are very common insects in the vicinity of streams, ponds and lakes, and as many of them are of

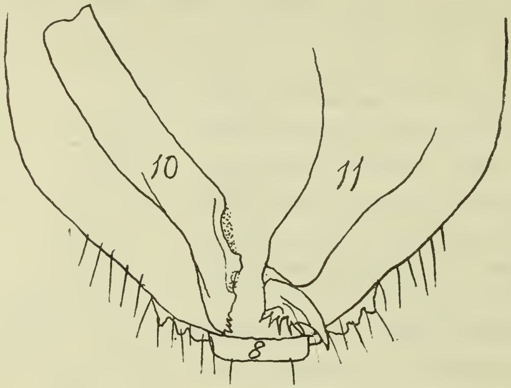


Fig. 21.

Mouth-parts of a spring-tail, *Entomobryidæ:* *8*, labrum; *10*, mandible; *11*, maxilla. (After Comstock's Introduction.)

large size and fly vigorously during the daytime they are well known. They are commonly termed "dragon-flies" and "darning-needles," usually modified by the term "devils;" also, "spindles" and "snake doctors." A very popular superstition regarding them is, that they sew up the ears of those persons whom they can catch. These insects can be counted as beneficial, since they feed only upon other insects and are exceedingly rapacious. Their food, however, consists in large part of mosquitos and small flies, whence they have also been called "mosquito-hawks," and as these are not directly injurious to vegetation, however annoying they may be to the farmer, these creatures are really indifferent. We have a considerable number of species of dragon-flies and some of them are very handsome. They have a very large head, with immense eyes and a formidable mouth, but have no sort of sting, as is often supposed. They lay their eggs on or in the water or on aquatic plants, and the larvæ live out their life in that medium, feeding as hungrily upon water animals and insects as do their parents upon those of the air. They have a most remarkable mouth structure, being furnished with an extensile lip, at the end of which is a pair of sharp jaws. When it is retracted, this lip acts as a mask, and the larva looks very innocent and harmless until some smaller

larva comes swimming along, when the mask is raised, the lip is extended and the cruel jaws close upon the hapless victim. The members of this series are easily distinguished, therefore, both in the larval and adult stages. When the larva is full grown it changes to a pupa, which is also active, and in due time crawls up the stalk of some water plant to the surface, or on some exposed stone, and there it rests quietly for a time until, finally, the skin of its back is rent and split and the dragon-fly emerges and soars off, leaving only an empty shell behind.

The *Ephemeridæ*, or "day-flies," also belong to this order, and are extremely interesting creatures, albeit of no importance to the farmer. They pass their early stages under water in lakes, rivers and streams,

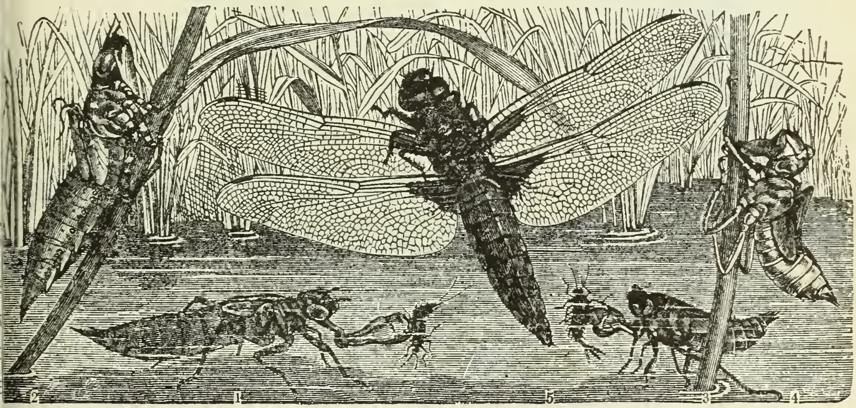


Fig. 22.

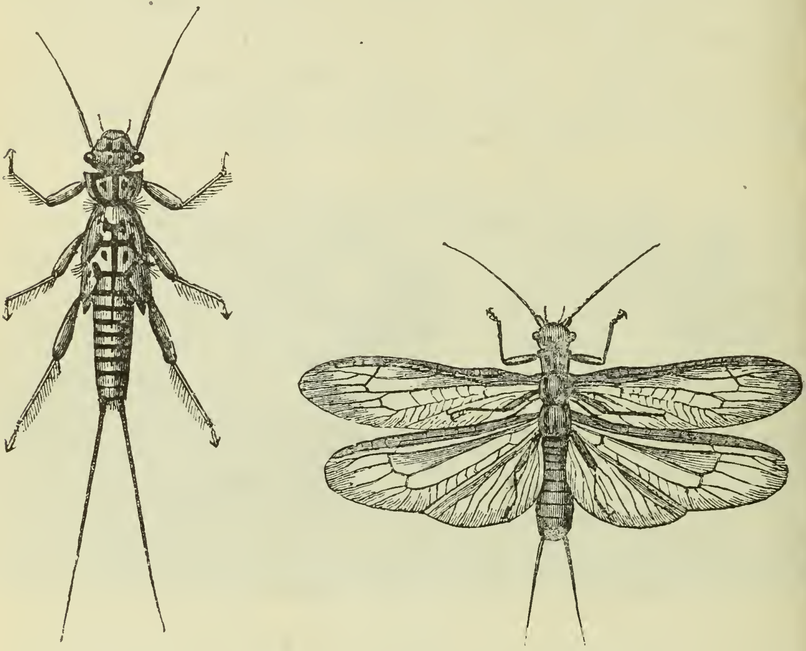
Metamorphoses of dragon-flies. 1, larva, and 2, larval skin of *Æschna*; 3, larva, 4, pupa, and 5, adult of *Libellula depressa*. (From Standard Nat. Hist.)

and make their appearance as adults in early summer, rising from the water about dusk in perfectly enormous numbers. They are strongly attracted to light, and bushels of them are often swept up under the electric lights of the cities on our Western rivers or on the lakes. They live as adults only a very short time—often a few hours only—and are easily recognized by their large fore wings, small hind wings and long anal filaments.

Other members belonging to this order are the "stone-flies," the larvæ of which are curious creatures living below the surface of the water and generally closely attached to the under sides of stones.

They are neither beneficial nor injurious and hence need not be more particularly described here.

Other forms of *Neuroptera* are the *Termites*, or "white ants," as they are usually called. These are very interesting creatures so far as their social habits are concerned, but are injurious rather than beneficial. In this State, however, where they occur in fields, it is generally in decaying rather than in healthy plants that they are found, and



a b

Fig. 23.

Stone-fly, *Perla bicaudata:* *a*, larva; *b*, adult; enlarged. (After Figuier.)

often they follow the attacks of other insects. So I have found in the roots of blackberries which had been attacked by borers and were beginning to decay, that these insects had commenced their tunnelings, and were certainly not aiding the plant in any way.

This is not the place to speak at length of the interesting habits of these creatures, but as they are so often seen it may be well to note that each colony consists primarily of workers which are not sexually developed and are unable to reproduce their kind. They are blind and shun the light, moving from place to place in tunnels constructed

by them, and they feed largely upon dead wood and other vegetable matter, though in some cases living plants are attacked. They assist

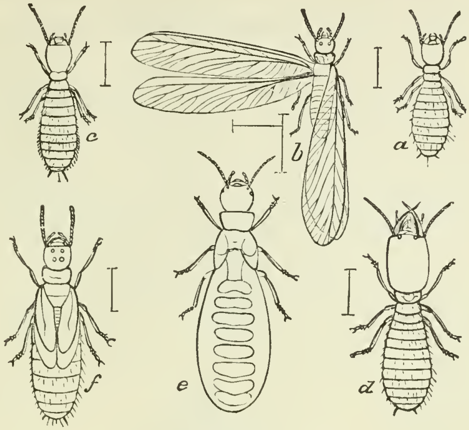


Fig. 24.

Termes flavipes: *a*, larva; *b*, winged male; *c*, worker; *d*, soldier; *e*, large female; *f*, pupa. (After Riley.)

greatly in reducing to dust fallen trees and stumps and are important factors in nature's routine.

The book lice also belong here, but have no economic importance, either as injurious or beneficial insects. They are often found in houses and are usually wingless, with long, slender antennæ or feelers and move about rapidly. They are sometimes mistaken for parasites, but are always distinguishable by their quick motions, the parasites for which they are mistaken being invariably sluggish. Other species are winged, and feed upon lichens and mosses on tree-trunks, where they are sometimes found in considerable numbers, huddled together. They have been accused, some-

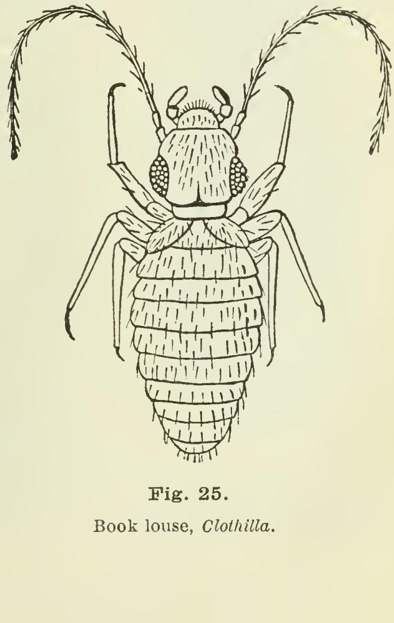


Fig. 25.

Book louse, *Clothilla.*

times, of injuring trees, but unjustly; they are harmless and never a source of injury to the husbandman.

The biting lice also find a place in this aggregation of types. They are parasites, which live on warm-blooded animals. They infest

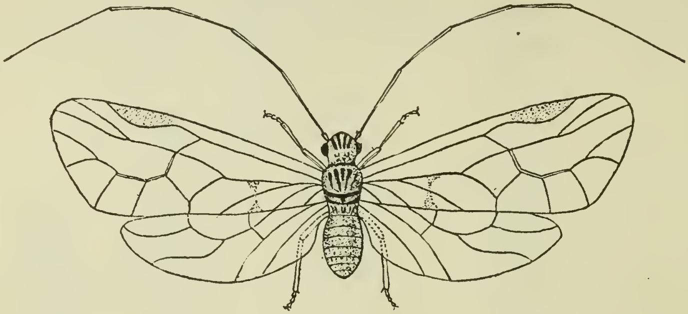


Fig. 26.

Psocus lineatus, enlarged.

chiefly birds, and on this account the term "bird lice" is applied to the entire group. A few genera, however, are parasitic upon mammals, and in all cases they feed upon feathers, hair and scales of the skin, never upon blood. The mouth parts are formed for biting only, and they have not the ability to pierce and suck, as have the suctorial lice. They belong rather to the injurious series, with which we have nothing to do at present.

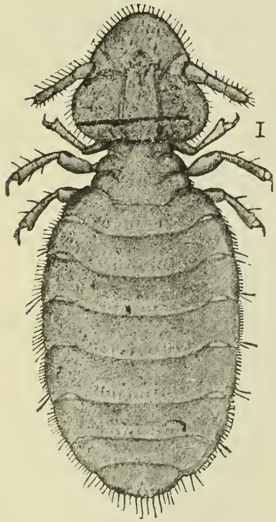


Fig. 27.

Cow louse, *Trichodectus scalaris*. From U. S. Dept. of Agri.)

The "dobsons," belonging to the family *Sialidœ*, are other insects which in the larva state live under water, and neither they nor the adults resulting from them having any economic importauce. They are of some interest, however, to fishermen, for the "hellgrammite," as the larva is termed, makes excellent bait, especially for bass. The male of this "dobson" is a formidable creature in appearance, from its huge jaws, but it is really a most

harmless form, and its immense mandibles are actually less powerful than the smaller but more robust structures of the female. The larva is a curious creature, living under stones in running water, and furnished with great tufts of hair laterally, which serve as tracheal gills, enabling it to get the necessary supply of air directly from the water.

A much more important group is that including the "aphis-lions" and "ant-lions," and these belong to the family *Hemerobiidæ.* They are delicate insects, as a rule, with large, though somewhat narrow, gauzy wings. The larvæ are predaceous and have a most curious modification of the mouth parts, by means of which, though they

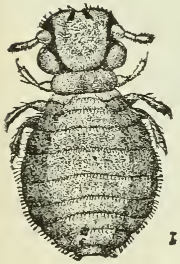


Fig. 28.

Dog louse. *Trichodectus latus.* (From U. S. Dept. of Agri.)

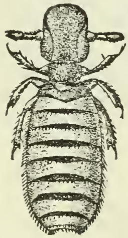


Fig. 29.

Sheep louse, *Trichodectus sphærocephalus.* (From U. S. Dept. of Agri.)

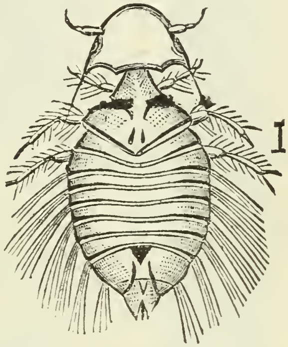


Fig. 30.

Turkey louse, *Goniodes stylifer.* (From U. S. Dept. of Agri)

have distinct mandibles and other organs for biting, they are yet enabled to suck the juices of their victims. The mandibles, or jaws, are very long and pointed, and are grooved on the inner side. The lower jaws, or maxillæ, are also very much elongated, and are fitted to enable them to close the groove of the mandible, and thus form a complete tube through which the insect is able to suck the blood of its victim—that is to say, the mandibles grasp the prey, pierce the skin and are then simply left in the wounds that they have made, the juices being sucked through them. Plant lice form a very large part of the food of these insects, and they are, therefore, directly beneficial to the farmer. These "lace-winged flies," as they are also called, are very common throughout the summer months, and are usually of a light-green color, or yellowish, the eyes brown and very bright, which has, in some localities, given them the name of "golden-eyed

flies." Many of the species, when handled, emit an extremely disagreeable odor, which probably serves them as a means of protection. A remarkable fact in the history of these insects is the way the female cares for her eggs. When about to oviposit, she emits from the end of her body a minute drop of a tenacious substance. This

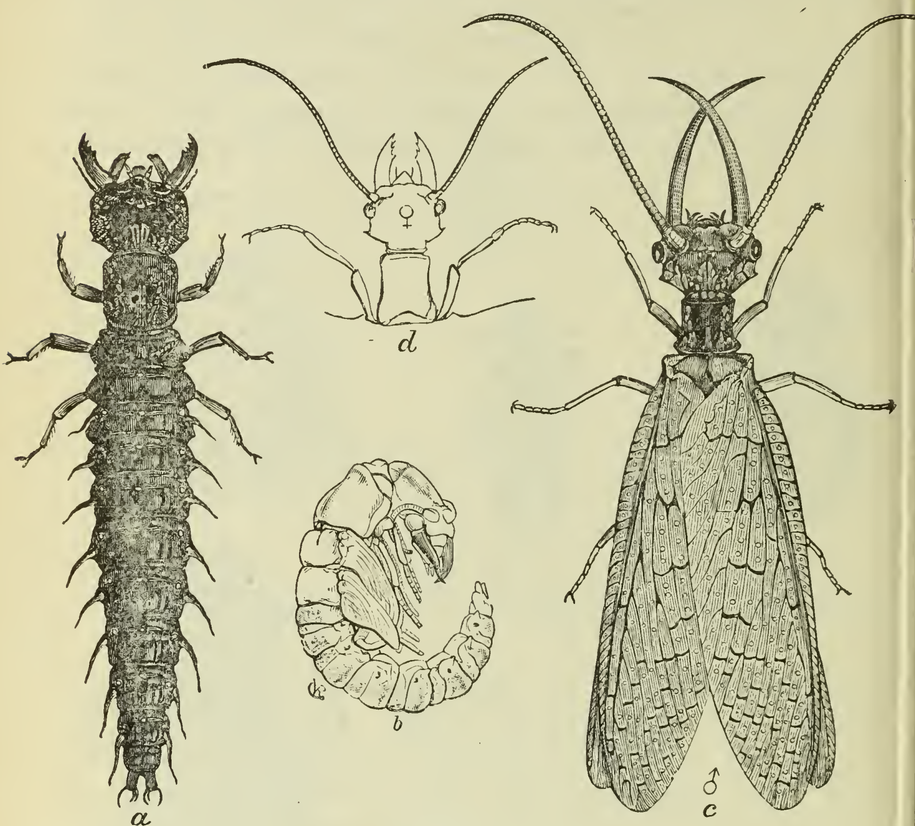


Fig. 31.

The hellgrammite, *Corydalus cornutus:* a, larva; b, pupa; c, male fly; d, head and jaws of female. (After Riley.)

is drawn out to a slender thread by lifting the abdomen, and then an egg is placed on the summit of this thread. The thread dries at once and firmly holds the egg in midair. When the young aphis-lion hatches, it crawls down the thread that holds up the egg and starts in quest of some insect which it can feed upon. The larvæ are spindle-shaped, and while they feed chiefly on plant lice, they

will eat also such other insects as they can overcome, particularly soft creatures, like the larva of the elm-leaf beetle. The cocoon in which the pupa state is passed is a perfect sphere, generally white in

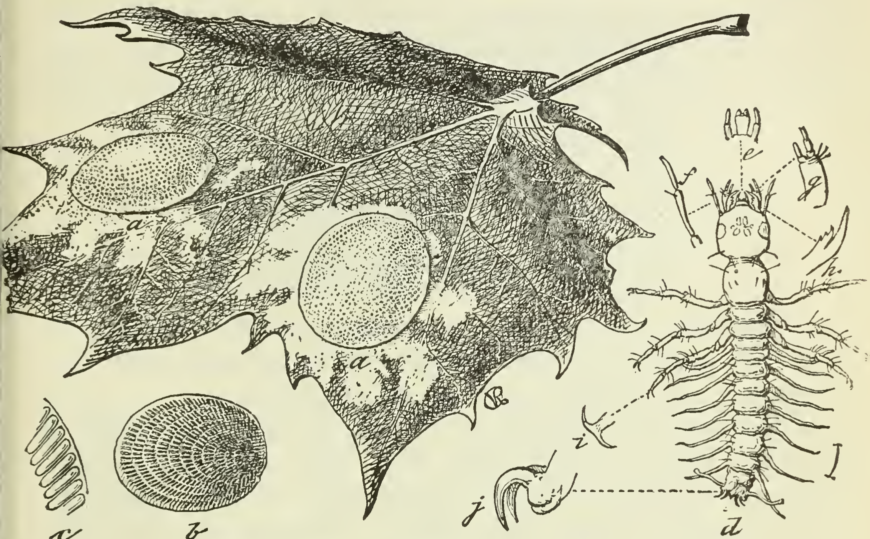


Fig. 32.

The hellgrammite: *a*, egg mass; *b*, same detached, from under side; *c*, single eggs; *d*, newly-hatched larva; *e* to *j*, details of larval structure. (After Riley.)

color, composed of dense layers of silk, and in order to emerge, the insect cuts a circular lid from one side. The adult, after it has emerged, does no feeding, and in that stage is found neither injurious

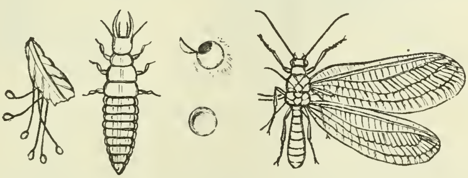


Fig. 33.

Chrysopa sp., lace-wing fly: *a*, eggs; *b*, larva; *c*, cocoon intact and after escape of *d*, adult. (After Riley.)

nor beneficial. Nor, indeed, is the larva one of nature's great checks on plant-lice increase, for it seems to prefer to spend its time on fences, or trees, or tree-trunks, and in similar situations, where it

picks up indiscriminately those insects that come into its way, and it is not usually seen in our cultivated fields. Yet, it is well to recognize the fact that we have here an insect that is at least a check to many forms of plant lice feeding on trees, and does good work often by feeding on soft-bodied slugs or grubs, like the larva of the elm-leaf beetle, which has been already mentioned. We have many species of these "lace-winged flies," but they are all closely related,

Fig. 34.
Lace-wing fly from side, and eggs.

look very much alike and have very much the same life history. We need not, therefore, go into further details, but recommend these creatures to the distinguished consideration of farmers.

Allied to the preceding family, we have the "ant-lions," which, in the adult stage, are larger insects, with much longer and comparatively yet narrower wings, and generally dark or gray, rarely green or brown colors. These insects have no unpleasant odor when being handled; but some of them have a habit of curling up the abdomen, which gives the idea that they have the power of stinging, although

Fig. 35.
Myrmeleon, ant-lion: larva and adult.

such is not really the case. The larva resembles, in its general appearance, that of the aphis-lion, but is rather broader and more robust and has still larger jaws. It has the curious habit of building pitfalls in sandy places, at the bottom of which it lies in wait, almost covered by sand, and watches for some unwary insect, generally an ant, to tumble into its pit. As soon as this happens, the insect seizes it by means of its formidable jaws and its life's blood is sucked in a

few moments. In case the insect does not tumble to the bottom of the pit at first and makes an effort to escape, our ant-lion quickly loads upon the top of its head a quantity of sand, and throws it with certain aim upon the struggling specimen, generally with the effect of

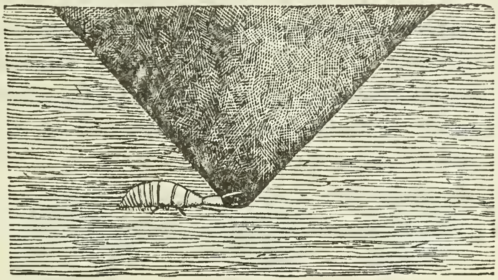


Fig. 36.
Section of pit of ant-lion. (From Standard Nat. Hist.)

bringing it within reach of its jaws. When it is full grown it forms a silken cocoon, very much as in the preceding series, but covered with grains of sand, which render it practically invisible in its surroundings. It is an interesting fact that this spinning is done from the anus instead of from the mouth, as is usual with insects. From this, in due time, issues the perfect fly, which is as harmless as its

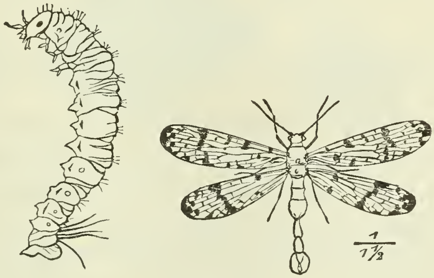


Fig. 37.
Panorpa, or scorpion-fly, and larva. (From Packard.)

larva was rapacious. As a matter of actual fact, these insects can scarcely be called beneficial, because the insects upon which they feed are not really injurious, and because their number is, comparatively speaking, so small as to have no perceptible effect in decreasing the number of its prey.

The scorpion-flies, or *Panorpidæ*, are remarkable creatures, which obtain their name from the peculiar anal appendage of the male,

which in a way resembles the tail of the scorpion and is curled up in a somewhat similar fashion. The mouth is prolonged into a very curious beak-like structure, and is entirely unlike that of any other family related to it. The larvæ somewhat resemble caterpillars, but live in the earth, making mines in every direction, or they may occur in moss on tree-trunks, and upon stones, and they probably feed upon insects found in such localities. They are predaceous insects and therefore to be classed among such as are beneficial, although practically they are of no value to the agriculturist, since the insects they feed upon are not injurious species.

Very curious insects are the "caddice-flies," so called principally from the habit that the larvæ have of building cases in running water.

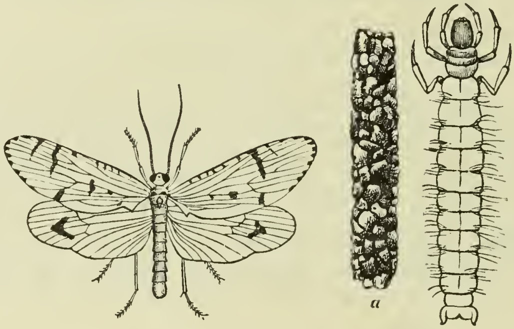


Fig. 38.

A caddice-fly, *Limnophilus rhombicus.* (From Standard Nat. Hist)

These cases are usually tube-like, and are formed of sticks, stones, leaves, or, in fact, anything in the way of rubbish that the specimens can get hold of; but each species builds a characteristic case, and those that use stones never use sticks, so that in many cases it is easy to recognize the species from the case alone. These insects sometimes occur quite abundantly in ditches and streams that flow through cranberry bogs, where there is a sufficient stream of water to enable the insects to flourish, and as they sometimes use cranberry leaves in building their habitations, they have been supposed to be injurious to this plant. As a matter of fact, however, the leaves that are used are such as have fallen into the stream and have not been torn from the plants by the insect. The larvæ, so far from feeding upon vegetation, feed upon all sorts of insects and other animal matter that they are able to find in the water, and while they are not beneficial in

the strict sense of the word, they are never in the least injurious. The adults are often found in numbers along the banks of streams and are quite readily attracted to light. They have the wings usually dark or dusky, sometimes colored and very frequently covered with hair or scales, resembling some of the lower moths, and when at rest they hold the wings in very much the same manner. The mouth parts are not well developed and they do not feed in this stage. Taken as a whole, we may say that in the order *Neuroptera* the great majority of the species are innoxious; that is, except in the aphis-

Fig. 39.

Caddice-fly cases. (From Standard Nat. Hist.)

lions, neither strictly beneficial, nor, except in the case of the parasites, at all injurious.

The order *Orthoptera* contains insects all of which, so far as our own State is concerned, may be reckoned as injurious. Some of them do little real injury, feeding upon plants that have no special interest or value to the farmer, but none that occur with us are beneficial. The only exception to the generally-herbivorous character of the order is in the case of the *Mantidæ*, also called "soothsayers," from the peculiar habit they have of holding their fore legs as if in the attitude of prayer. These are predaceous and feed upon whatever

insects are foolish enough to venture within their reach, but they do not occur in our State except as rarities in the southern counties. Other members of this order are the cockroaches, crickets, grasshoppers, locusts, katydids and the like, and these are treated at some length in Bulletin No. 90 of the College Station, and in the Annual Report for 1892.

Cockroaches are almost omnivorous, and are said to devour other insects when pressed for food; they have also been credited with eating bed-bugs on occasion. So, crickets sometimes eat other insects and occasionally each other; the tree-crickets, especially, or some of

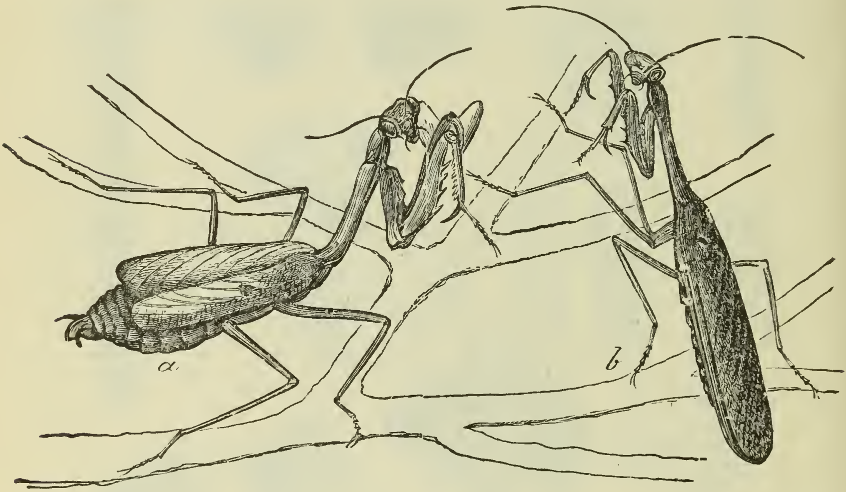


Fig. 40.

Stagmomantis carolina: *a*, female; *b*, male. (After Riley.)

them, being said to be quite fond of varying their usual vegetable diet. Yet, none of these could be properly called beneficial, and all the members of this order, as they occur in this State, may be considered as enemies to agriculture.

The order *Hemiptera* contains insects that obtain their food through a jointed beak, in which run pointed lancets, which can be used for piercing the material upon which they feed, and by this mouth-structure the insects belonging to the order *Hemiptera* can always be recognized. They are what the entomologist calls "true bugs," and, as a whole, the members of this order are injurious. They contain such insects as the "scale lice," "bark lice," "plant lice," "thrips,"

"chinch-bugs," "bed-bugs" and the like. They have four wings, and on their character the order is divided into two main sections, in the first of which both pairs of wings are transparent or, at least, similar in texture, while in the other, the fore wings are partly thickened and of a leathery or even horny texture toward the base, while the tip is membraneous. In the first series, which are also called *Homoptera*, there are none that can be, in any sense of the word, called beneficial, and therefore all insects of this character which obtain their food through a jointed beak may be called injurious. Yet, even this series contains some insects that are of some importance, economically, other than as pests; for we have belonging here the cochineal insect, from which a most beautiful dye is secured; the lac insect, from which scale-lac is obtained, and the wax insect, from which, in China, a very useful wax is made. Yet, these are only apparent exceptions, for they are really destructive to the plants on which they feed; it happens merely that in these cases the insects are of more value to man than the plants. The case is somewhat different with the *Heteroptera*, as the second section of this order is termed, and many of these are predaceous, feeding upon other insects. It is somewhat difficult in all cases to say which of the members of this order are predaceous and which feed upon plants. First, all those that live in the water are predaceous, but they can hardly be called beneficial, for they do not feed upon insects or forms that are injurious to growing crops. Of the land insects, some are very indifferent where they obtain their food-supply, and they will spear a larva or puncture a leaf, just as they happen to feel or as opportunity serves. These can scarcely be called beneficial, even though they may not be

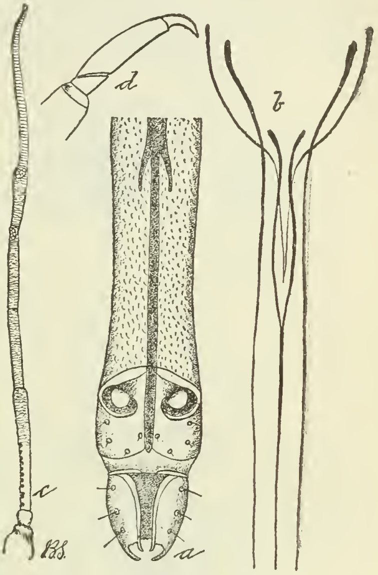


Fig. 41.

a, beak of wheat louse; *b*, the lancets contained in it; *c*, antenna, showing the sensory pits; *d*, tarsus. (Original.)

actively injurious. There is, however, one group of the *Heteroptera*, largely belonging to the family *Reduviidæ*, which is entirely predaceous, and they can generally be recognized by the very small head, which is yet very distinct, and the small, though prominent eyes, set upon the sides. They also have the beak short and stout, only a very little curved and apparently arising from the front of the head. The largest of our species belonging to this series is known as the "wheel-

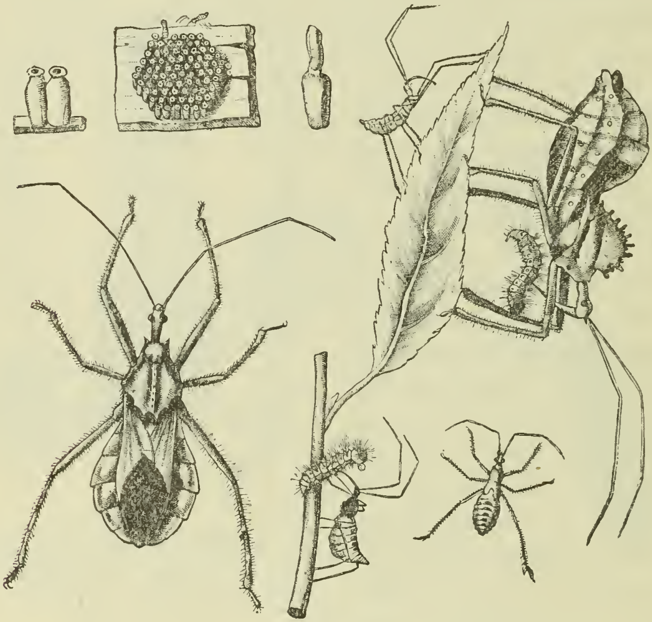


Fig. 42.

Prionidus cristatus, the "wheel-bug:" eggs, larvæ and full-grown specimens. (After Glover.)

bug," and is more common in the southern portion of the State. It gives a very good general idea of the appearance of the predaceous forms, although there is a considerable range of variation in size and color. All of the bugs with the head structure shown in the outline Figure 43 may be counted as beneficial or, at least, not actively injurious. All others of the *Heteroptera* should be looked upon with suspicion, although there are some forms belonging to the series in which the body is short and broad, with the head and thorax forming a triangle, largely belonging to the family *Pentatomidæ*, which feed occasionally, or even as a rule, upon other insects. Of this character

is the *Podisus spinosus,* or spined soldier-bug, a clay-yellowish species with minute black speckles, which, among others, feeds upon the larvæ of the Colorado potato-beetle, destroying no inconsiderable number, and it has allies that resemble it in appearance and have similar habits. Among these *Pentatomids,* there are few in our State that are actively injurious, and perhaps the good done by other members of the family may overbalance the ill suffered at their hands. We also find, quite usually, that where bugs are predaceous in their habits, the fore legs are either stout and strong or armed with claws, or spurs, or spines, enabling them to grasp their prey. The appearance of

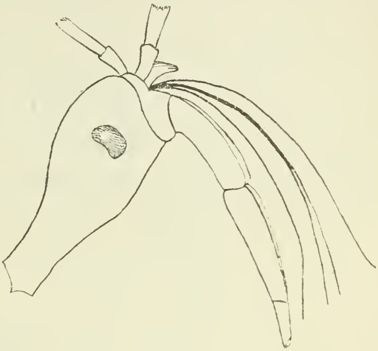


Fig. 43.
Outline of head and beak of predaceous *Hemiptera.* (Original.)

some such leg structures is shown in Figure 46. The metamorphosis in the *Hemiptera* is incomplete—that is to say, the larva and the imago resemble each other, except that the former is never winged and there is no quiescent pupal stage. The predaceous species are

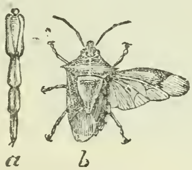


Fig. 44.
Podisus spinosus: *a*, enlarged beak; *b*, bug, with right wings expanded. (After Riley.)

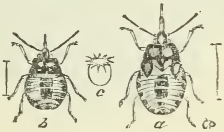


Fig. 45.
Podisus spinosus: *a*, pupa; *b*, larva; *c*, egg. (After Riley.)

useful, therefore, during their entire life, and they, undoubtedly, do considerable good. A quite notable feature in many of the *Heteroptera* is their odor, which is extremely unpleasant and quite characteristic. It is marked in the bed-bug, and is most marked, always, in the plant-feeding forms, though even the predaceous types are not free from it. In the well-known squash-bug, the odor is of a peculiarly sickening, musky character, which is less usual. Even the

eggs have this peculiarity, as is sometimes unpleasantly manifest when one of them is chewed with a blackberry or raspberry. As a whole, it may be said that few of the insects belonging to this order are actively beneficial or of any advantage to the farmer.

Fig. 46.

a, fore leg of *Reduvius; b*, fore leg of *Phymata.*

The order *Lepidoptera* includes the butterflies and moths. These insects are well known and it scarcely needs a description of the adults or perfect insects. They have four wings, usually of comparatively large size and densely clothed with scales of various forms which, when the insect is handled, rub off readily and appear on the fingers like dust. Under the microscope, however, it is seen that they have definite forms, some of them very beautiful, and that there are scarcely two species in which all the scales are exactly alike. The mouth is formed for sipping liquids and consists of a long, flexible tongue, which is coiled, when at rest, under the head. This tongue in some of the hawk moths, becomes enormously elongated, and in some of our species is from six to eight inches in length, able to reach to the bottom of the deepest flowers,

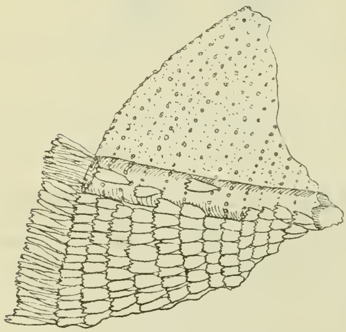


Fig. 47.

Fragment of butterfly-wing, partly denuded of scales, much enlarged. (Original.)

to reach the nectar that is concealed there. In the moth state these insects are neither beneficial nor injurious, strictly speaking, although some of them are useful in so far as they aid in the cross-fertilization of flowers and fruits, carrying pollen from one blossom to the other: indeed some flowers are entirely dependent upon the moths that visit them for fertilization. To this extent only they are advantageous to the farmer. Their caterpillars are, in almost every case, injurious, and among the most destructive insects that we have are the larvæ of the *Lepidoptera*—"cutworms," "measure-worms," "webworms," "apple-worms," all belonging to this order. They can always be distinguished from the larvæ of all other insects by

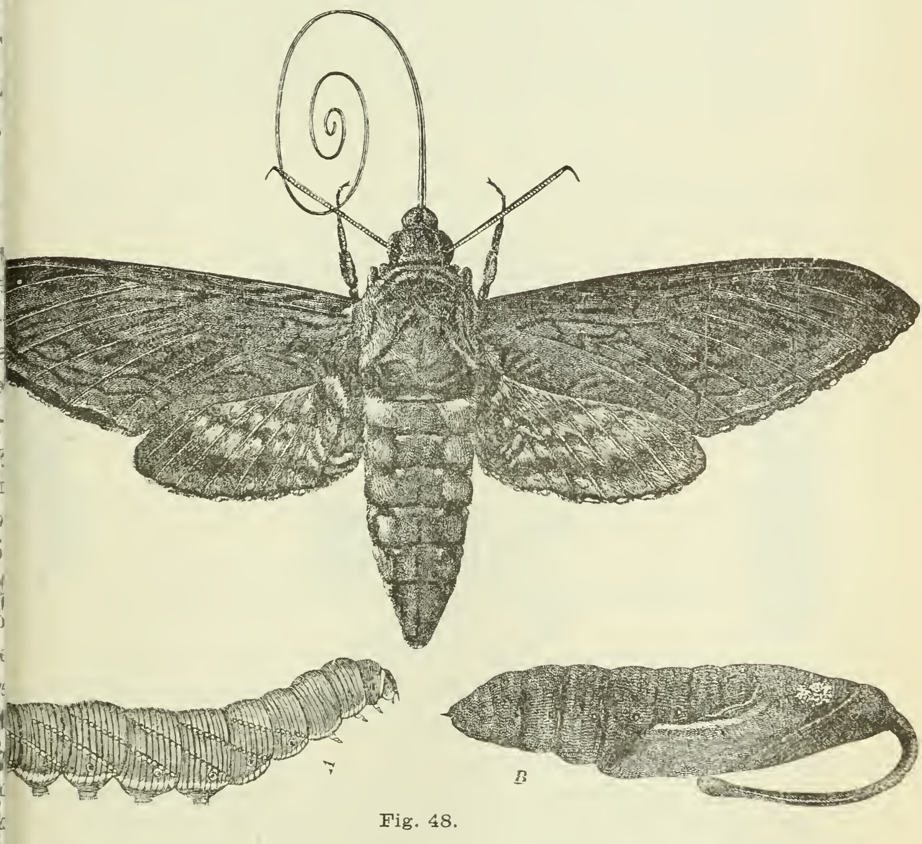


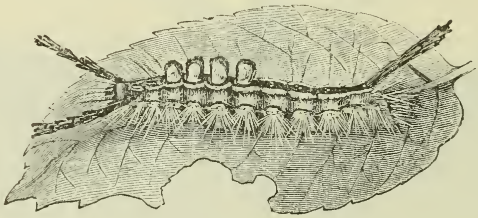
Fig. 48.

Potato-worm hawk-moth, *Protoparce celeus:* *a*, larva; *b*, pupa; *c*, moth, showing elongated tongue. (After Riley.)

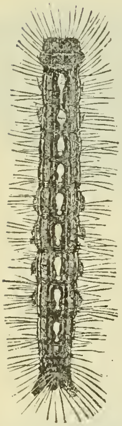
having, besides the three pairs of true legs, from one to four pairs of false legs in the middle of the body and another pair at the posterior end. Never do they have more than the number of legs above given, although they may have less, and eight pairs of legs always indicate the larva of a butterfly or moth. The larvæ of certain of the saw-flies resemble caterpillars very strongly and are sometimes known as "false caterpillars," but they have one additional pair of pro legs which renders them in all cases easily distinguishable. There are few rules without their exceptions, and we do even find certain exceptions to the general herbivorous character of the caterpillars. The larva of *Fenesica tarquinius*, one of our butterflies, feeds among the colonies of a certain woolly plant louse, while the caterpillar of one of the snout moths, or *Pyralids*, feeds upon bark lice. Among exotic forms there are several others that have a carnivorous habit, but neither of the species that occur in our State are of any practical

Fig. 49.

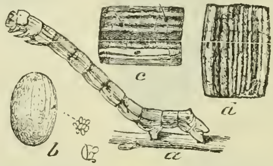
CATERPILLARS.



Vaporer-moth larva.



Forest tent-caterpillar.



Canker-worm.

Army-worm.

(All from Riley.)

importance to the farmer. They do not feed upon species that injure his field crops, and in any case they are found with us so rarely as to require close search to find them. So far as New Jersey is concerned we can take it for granted that none of the *Lepidoptera*, either in

their larval or adult stage, are beneficial, and at the best they are only innoxious. Caterpillars may therefore be safely destroyed at any time.

The order *Diptera* includes the two-winged flies, and here we have an order in which we find insects that are directly beneficial and that are directly injurious, though, as usual, the majority are indifferent. It is not easy to distinguish one from the other, and indeed, within the limits of the same family, we may have species that are beneficial and species that are injurious. The members of this order can be distinguished in their adult stage by the presence of but two wings, which are absent only in certain degraded parasitic forms. The "sheep-tick," for instance, is a fly that has lost its wings on account of its parasitic mode of life, although many forms that are closely related to it, and are parasitic upon birds, have the wings well developed. The most degraded form is the "bee louse," which has lost all its resemblance to the order to which it belongs, and is blind as well as wingless.

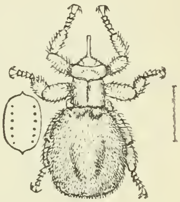


Fig. 50.

Sheep-tick. *Melophagus ovinus.*

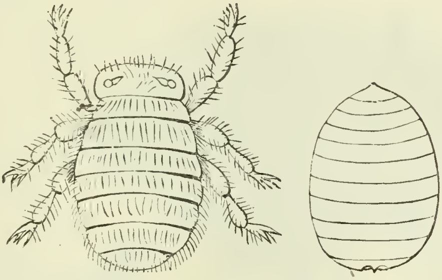


Fig. 51.

Bee louse, *Braula cæca*: *a*, its larva; *b*, adult. Greatly enlarged.

No fly has more than two wings, and this character always serves to distinguish the order *Diptera*, which means "two-winged." The fleas are usually classified as belonging here, although they have no wings at all in any species. There is considerable ignorance concerning the life history of the fleas, and though they can scarcely be termed beneficial, a few words on the subject may be excused. The adults, as is well known, infest warm-blooded animals, subsisting upon their blood. When the females are impregnated and ready to

lay eggs, they leave their host, usually while it is at rest in its den or lair, or lying down in a suitable place, and the eggs are dropped loosely to the ground. From these eggs hatch little, white, worm-like larvæ, with black heads, which feed on damp vegetable matter

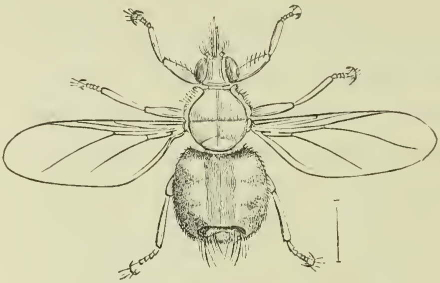


Fig. 52.

"Bird-tick," *Olfersia*, sp.

or rubbish of all kinds. A heap of sawdust or shavings is an ideal spot, and in the spaces between the boards of flooring there is always an accumulation of dirt that suffices to feed them. When the larvæ

Fig. 53.

Rabbit-flea, *Pulex cuniculi* (?), greatly enlarged. (From a photograph.)

are full grown, they change to the adult or flea state, and then hop about until some suitable animal comes within their reach. Among the flies, we find very extraordinary developments of mouth

structures. They are sometimes made into formidable weapons like those of the horse-flies, and of the mosquitoes, and are sometimes formed like those of the ordinary house-fly, simply for lapping. In no cases are they formed so that the fly can eat solid food; it must always be taken in the form of a liquid. When a fly attacks a lump of sugar, therefore, it first moistens it with a drop of its own saliva, and the sugar, so far as it is dissolved by this drop, is pumped into the stomach of the fly. Flies are, in consequence, most readily attracted to liquids and to material that is decaying or undergoing fermentation, where the solids are breaking up. There is a very great difference in the larvæ in this order; but, perhaps, the larger proportion of them will come under the head of "maggots." Many of these maggots have a very distinctly beneficial influence, for if they do not actually destroy other insects which injure the farmer, yet they assist in removing dead material, both of vegetable and animal origin, and in changing its form so as to enable it to return to the soil from whence it came and to be assimilated again by plants. It has been said that flies could devour an ox quicker than could a lion, and though this is somewhat exaggerated, still, under some circumstances, it is surprising how rapidly even a large carcass is made away with by these insects.

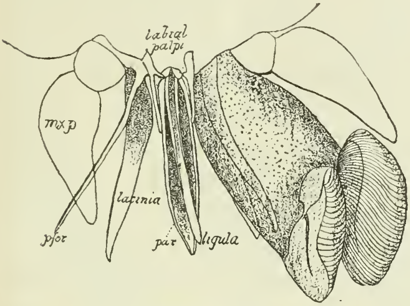


Fig. 54.

Mouth parts of *Tabanus* or horse-fly. (Original.)

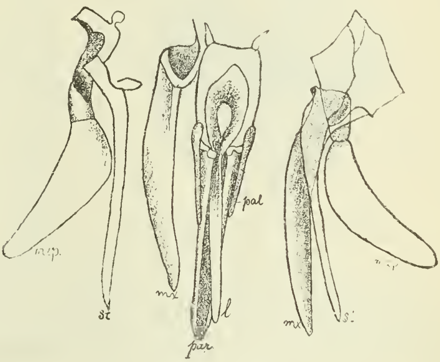


Fig. 55.

Mouth parts of horse-fly, showing lancets dissected out. (Original.)

In the great group of midges or *Cecidomyidæ* we count many most troublesome forms. We have the "cranberry midge;" the "pear

midge," which is treated in a previous part of this report; the "wheat midge," the "Hessian fly," the "clover-seed midge" and many others which are certainly in no sense of the word anything but most injurious. We also have certain species that feed in the galls of phylloxera, and others that feed on forms of plant lice or even other insects, but these are rather exceptions and do little real good to the farmer. We may say, generally, that the midges are injurious rather than beneficial, and midge larvæ, or midges themselves where they are observed, should be looked upon with suspicion, and especially where they are observed in plant tissue or on fruits. The midges resemble, generally, a mosquito, and some of them are exceedingly small. The figures that are given herewith illustrate the usual form of midges and of their larvæ. The latter are generally long, oval, slightly flattened, that is to say, hardly cylindrical, a little pointed, as a rule, toward the head, and generally furnished with a curious little brown hook, which is called the breast bone, but is really a part of the mouth structure and serves the insect for scraping the tissue of the plant in which it feeds.

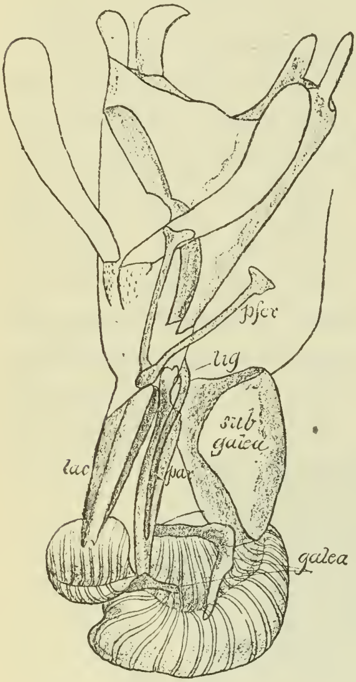


Fig. 56.
Mouth of blow-fly. (Original)

Somewhat allied to the midges in appearance are the fungus gnats, belonging to the family *Mycetophilidæ*. Of these we have many species, feeding not always upon fungus, but sometimes upon exudations from trees, or even in decayed woody matter. The larvæ of one genus at least, *Sciara*, have been long known for their gregarious habits. When about to change to pupæ, they assemble in immense numbers, forming processions that have been observed four or five inches wide and ten or twelve feet long. They travel in a solid column from four to six deep, over each other, advancing about an

inch a minute. From this peculiar habit, they have been called the "army-worm" in Europe, but are, of course, quite a different insect from that which has been honored with the same name in this country. These larvæ are long and slender and have a black head in most instances. None of them can be considered as beneficial, and in some few cases they actually become injurious, as, for instance, when mushrooms are raised for market.

Fig. 57.

Cranberry midge: *a*, ovipositor of the female, enlarged. (Original)

Passing over a number of families, including the "black flies" and several forms allied to the true mosquitoes, and the mosquitoes themselves, which are scarcely to be reckoned among the beneficial insects, we come to the *Tipulidæ* or "crane flies," or "daddy long-legs," which also have a mosquito-like form, although usually many times larger. The mouth parts are not formed for piercing, and the enormously-developed, slender legs are quite characteristics. The larvæ are long and slender; most of them live

underground, on woody material, including therein the roots of quite a number of plants, and they are often known as "wire-worms," and correspondingly injurious. They are mentioned here only as the last family of the series of flies that have long antennæ or feelers. In a general way, and for all the purposes of this paper, we can say that none of the two-winged flies that have long feelers or antennæ can be looked upon as really beneficial insects in any stage;

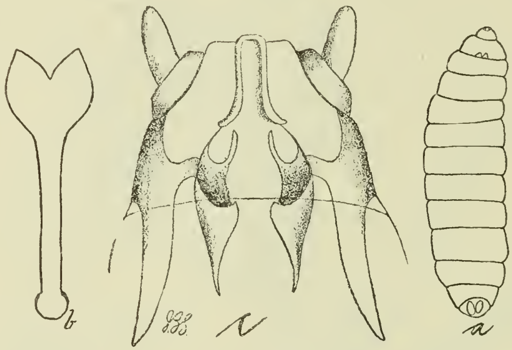


Fig. 58.

Cranberry midge: *a*, larva; *b*, breast bone of same; *c*, mouth parts. Greatly enlarged. (Original.)

for although, as I have already stated, some of the midge larvæ are predaceous in their habits, and others live in the water, doing at least no active damage, yet a very large number indeed of the species that have an interest to the agriculturist are active feeders upon vegetation, and in some cases upon our most important crops. The discussion of these does not belong to this article, and it will suffice to repeat again that flies, large or small, with long and many-jointed feelers, are to be looked upon as enemies rather than friends—to be destroyed rather than fostered, as opportunity serves.

The remainder of the flies have the antennæ short, and as a rule not more than three-jointed, although sometimes the last joint may be ringed in such a way as to give the impression of a number of segments. We have first in this series the forms which are and which resemble the horse-flies—large species, or at least of moderate size in most instances, with a vile habit of attacking animals and man, puncturing the skin and sucking blood. The mouth parts are formed of quite an elaborate set of lancets or piercing organs, as shown in Fig-

ures 54 and 55, by means of which the flies can, almost in an instant, puncture the thickest skin and draw blood. They are certainly not to be considered as beneficial insects in any sense of the word. Their larva do have some economic value and are carnivorous as a rule. Many live in the earth, others in the water. They are predaceous upon snails and injurious insects, thus in a measure repaying the agricul-

Fig. 59.

Crane-fly, *Pachyrrhina*, sp. (?) (After Webster.)

turist for the molestation they have caused him. The young larvæ are known to penetrate those of beetles and of other orders, and remain within them until they have completely consumed them, and we find thus an approach to a parasitic habit. Unfortunately the tendency of these larvæ is not to live in cultivated fields, but rather in woods or in low meadows, and hence, although the larvæ may destroy a great number of plant-feeding insects, yet they do not trouble those pests that are of serious importance to the farmer.

Horse-flies and their allies can therefore be considered as more troublesome than beneficial on the whole, and need not be favored at any time.

The family *Asilidæ* contains the "robber-flies." They are mostly large, some of them very large indeed, one species measuring two

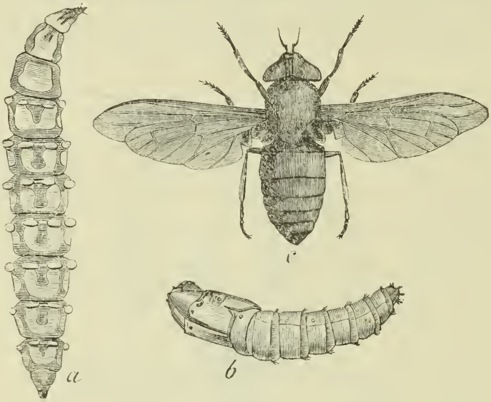


Fig. 60.

Tabanus atratus, black horse-fly : *a*, larva ; *b*, pupa ; *c*, imago (After Riley.)

inches in length. The wings are narrow, the abdomen is very long and spindle-shaped, the head is large, with a powerful, piercing mouth, and the legs are stout and set with spines. They are the most predaceous of all flies, and indeed one might say of all insects. A great part of them rest upon the ground and fly up, when disturbed, with a quick, buzzing sound, only to alight again a short distance ahead. All their food, which consists wholly of other insects, is caught upon the wing. Their luckless victims when once seized by their stout, strong legs are powerless to escape. They are not particular in their choice, and any insect flying by them is at once pounced upon as by a hawk.

Fig. 61.

The bee-killer, *Asilus missouriensis*. (After Riley.)

I have frequently observed them carrying off grasshoppers, and in several instances have seen even quite large beetles attacked, the beak

being inserted between the thorax and elytra or wing covers. These might be considered as distinctly beneficial forms were it not that they have an unfortunate habit of attacking bees as well as other insects, and one species has been recorded as having destroyed as many as one hundred and forty-one honey bees in a single day. Their habit, too, of attacking only flying insects reduces their usefulness to a considerable extent, and the more so as they rather favor large forms, while among our injurious species perhaps the majority are small and in themselves insignificant. So indiscriminate are these creatures in their destructive tendencies that they do not even spare their mates, and unless the male is very careful the female, in return for favors received, will spear him and kill him. The larvæ are cylindrical, or somewhat flattened, with a parchment-like skin, without legs or with only abdominal protuberances. They live chiefly underground or in rotten wood, especially in places infested with grubs of beetles upon which they feed. The young may burrow their way completely within beetle larvæ and remain until they have consumed them. Many are found, however, where they evidently feed upon rootlets or other vegetable substances.

Fig. 62.

The bastard robber-fly, *Erax bastardi*: *a*, fly; *b*, its pupa. (After Riley.)

They undergo their transformations in the ground, the pupæ have the head provided with tubercles, and on the abdominal segments there are also spiny protuberances and transverse rows of bristles, which aid the insects to reach the surface when they are ready to escape as flies. "Robber-flies," therefore, are to be encouraged, since none of them in the larval state are actively injurious, while many are distinctly beneficial and, except so far as the bee-keeper is concerned, the adult flies themselves may be considered as being decidedly beneficial in the true sense of the word.

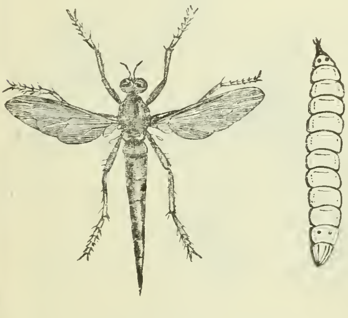


Fig. 63.

Silky robber-fly, *Asilus sericeus*, and its larva. (After Riley.)

Next follows a little series of insects to which the name "bee-flies" has been applied, from the resemblance which many of them bear in appearance to bumble-bees, although their habits of flight are quite different. They may be seen hovering over flowers, poising them-

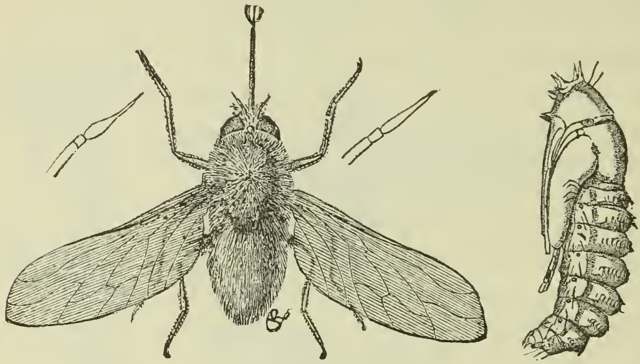


Fig. 64.

Systœchus oreas: bee-fly parasite on grasshopper eggs; fly and pupa. (After Riley.)

selves like humming-birds and darting off as rapidly if disturbed. Frequently they are found on sandy roads or patches, sometimes alighting, but always ready to take flight. A few forms are more sluggish, with shorter tongues, and these are often found on flowers, walking over them quite deliberately. Two families are represented,

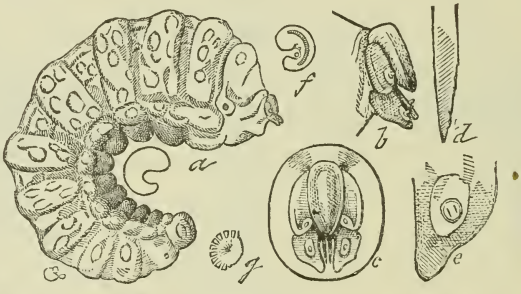


Fig. 65.

Larva and details of structure of bee-fly, *Systœchus oreas.* (After Riley.)

which need not be distinguished for our purpose. They are generally heavy-bodied insects, black and yellow in color, very frequently with a golden appearance, though sometimes with a fine silvery white

luster, and they are remarkable in some instances for their greatly-extended mouth parts. One species from Africa particularly, which although only about two-thirds of an inch in length, has a proboscis nearly three inches long, enabling it to suck the nectar from long-tubed flowers like *Gladiolus* and its allies. Not all of the bee-flies have the tongue so greatly lengthened, but all of them have very much the same food habits, and in all of them the mouth parts are so constructed that they cannot use them to pierce, but are confined to liquid food. They are thus neither beneficial nor injurious to the agriculturist, but the larvæ belong decidedly to the category of beneficial insects. So far as we know about them they are predaceous or actually parasitic. In some cases the eggs are laid within the channels of wood-boring insects, although the larvæ may not in each case feed upon the makers of the borings.

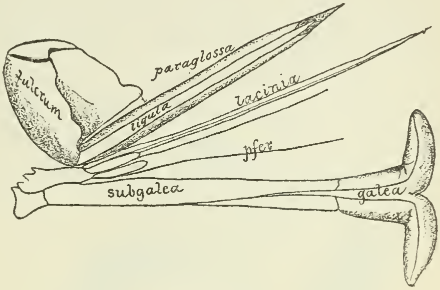


Fig. 66.
Mouth parts of long-tongued bee-fly. (Original.)

In the true bee-flies, *Bombyliidæ*, the larvæ are parasitic and predaceous, and among the most useful of these are certain forms like the *Systœchus*, above figured, that feed upon the egg-pods of grasshoppers. Some of them are also parasitic in the nests of bees, and probably of other insects, and some genera are quite usually parasites on caterpillars. We know the life history of only a comparatively few forms belonging to this order, but so far as we do know, they are insects to be well considered, and are directly beneficial in the sense that they lessen or keep in check some of the forms that are really injurious to the farmer. The bee-flies, therefore, should not be disturbed, and their abundance should be considered an advantage worthy of notice.

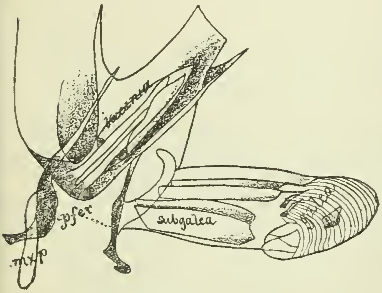


Fig. 67.
Mouth parts of short-tongued bee-fly. (Original.)

There follow in the natural classification a number of families, some of them containing a very large number of species, and of quite diverse forms, though perhaps the most numerous are those having a certain resemblance in appearance to the "robber-flies," and belonging to the family *Empidæ*, which have also much the same predaceous habits, feeding upon other insects, but principally flies of all kinds. The larvæ in these families are generally slender and elongate, sometimes with and sometimes without distinct feet, and in most cases they live in the earth, where they feed, probably, upon other insect larvæ, and in some cases it is likely also upon decaying vegetable matter.

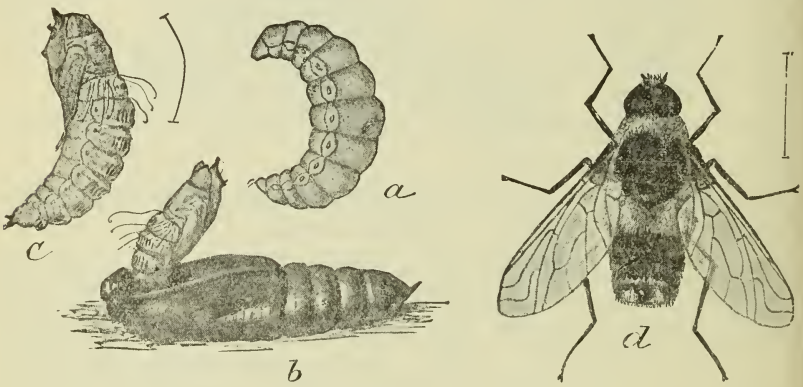


Fig. 68.

Anthrax hypomelas, bee-fly, parasitic on cutworms: *a*, larva; *b*, pupal skin protruding from cutworm chrysalis; *c*, pupa; *d*, fly. All enlarged. (From "Insect Life.")

They are, therefore, in a sense beneficial, although, as they prefer woodlands or brushlands, especially in the vicinity of brooks and streams, and are not commonly seen in cultivated fields, their actual importance to the farmer is not great. One species, belonging to the genus *Scenopinus*, lives in houses quite generally, and is smaller and less robust than the house-fly, and of a somewhat metallic hue. Its larva is a very long, slender creature, and is quite frequently found under carpets, where it is looked upon with suspicion by the careful housewife. As a matter of fact, however, the larvæ do not feed on woolens or upon anything treasured by the ladies, but rather upon those creatures that do injure carpets and the like, among others the so-called "buffalo moth" and the "carpet moth," although their principal food is probably the small paper lice, which are not unusually found in dwellings where the walls are papered. Some of

the flies belonging to this series are very prettily colored, metallic blue and green, with delicate wings and unusually long legs, which in one family, called the *Dolichopodidæ,* are sometimes peculiarly clubbed and paddle-shaped in the male. All of these small, long-legged flies that are blue or green and metallic in color, may be looked upon as friends, or at least not as active enemies, since they do not in any case feed upon vegetable matter which is of interest to the farmer.

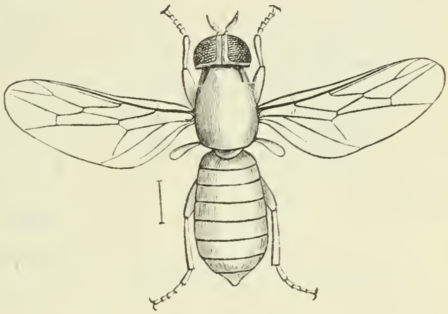


Fig. 69.
Scenopinus fenestralis. (From "Packard's Guide.")

Now follow the series of species in which the larvæ have the typical maggot-like form more or less distinctly marked. The head is never distinct, the first segment is never hard, and has soft, wart-like feelers, or it is even entirely without appendages, showing only a mouth opening. The body is cylindrical or somewhat flattened, smooth, or with swellings for locomotion, or with girdles of short bristles, sometimes with thread-like filaments. The larvæ shed their skins two or three times before assuming the pupal stage, escaping through a rent at the posterior end. The pupæ are always inclosed in the contracted larval skin, the adult insect escaping through a circular orifice at the anterior end.

The first family belonging to this series is the *Syrphidæ,* which is a very interesting one from any standpoint, and is one that is of considerable importance to the farmer. The larvæ differ quite considerably in appearance and fully as much in habit, while the flies resemble each other very much more, and are gayly colored, red and yellow banded, and frequently clothed with hair, sometimes so densely as to resemble bees. Others of these flies resemble wasps quite closely, and very frequently mislead the casual observer. One set of the larvæ of some of our larger species are parasites in the nests of bumble-bees; others feed in decaying and excrementitious matter. The latter are furnished with a curious

Fig. 70.
Rat-tailed larva of *Eristalis.* (From "Packard's Guide.")

appendage resembling a tail, and they are called rat-tailed larvæ in consequence. This is, however, not a tail in any true sense of the word, but is rather an arrangement to enable the larva to breathe. It lives in the midst of its food, surrounded by it on all sides, and in such a medium there is no possible chance of getting air from the surroundings. The tail is therefore extended to its full length so as to reach above the foul masses and through the tip of this structure, which is really a flexible tube, air is obtained, and a communication with the outer world is established. The flies hatching from these larvæ resemble bees very strongly in appearance, and they make a loud buzzing sound in their flight. They very frequently enter rooms in the fall, and buzzing about and against the windows are quite usually mistaken for bees. These flies are not infrequent in greenhouses, and by some florists they are known as "chrysanthemum-flies." They appear at about the time that these flowers are in bloom, and are supposed to be the agents required to fertilize them. Exactly how much truth there may be in this is by no means determined as yet, but at all events the insects are certainly not injurious in any sense of the term. The forms, however, that are of the greatest interest to the agriculturist are those which in the larva state feed upon plant lice, and of these there are a very great number of species. Many of them belong to the genus *Syrphus*. They are usually not very large, rarely more than one-half an inch in length, quite as pretty as most others of the family, and are remarkable for their rapid motion in the air, and for the

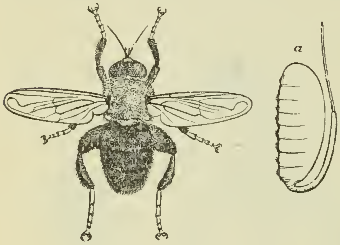


Fig. 71.

Mallota posticata: *a*, its pupa case. (From "Packard's Guide.")

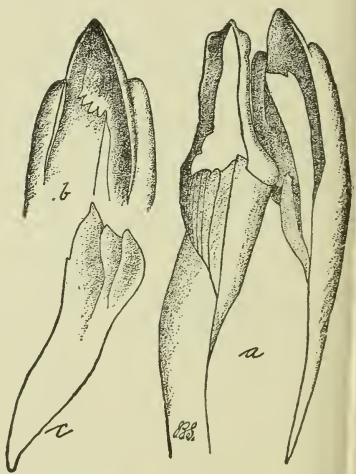


Fig. 72.

Syrphus torvus, mouth parts of larva: *a*, the complete mouth; *b*, the upper jaw; *c*, the mandibles. (Original.)

way in which they hover over flowers. The larvæ are cylindrical maggots without a head, and the mouth parts are apparently formed of from two to four outwardly-bent hooklets. The eggs are deposited by the females upon plants that are infested by plant lice. The young larvæ as soon as hatched crawl over the stems and leaves until they come in contact with the lice, which they pierce with the hooklets, and holding them up, suck out their juices, to the number of a hundred or more daily. When ready to undergo their transformations they attach themselves to the leaves, and the larval skin contracting forms an oval puparium. These flies are of very decided importance and of the most direct benefit to the agriculturist, and they fortunately prefer the open fields and are therefore likely to appear just where they are most needed by the farmer. There is no more important agent in this State for checking such creatures as the wheat plant louse, and I have already called attention to the species that is most abundant in this good work in Bulletin 72 of the Station. The figures showing the fly, the larva, and its mouth structure are reproduced here in order that they may be recognized under all circumstances. When, a few years ago, the wheat lice became unusually abundant in this State, it was seen to be impossible to pick off an infested wheat head without finding one or two of these larvæ, and wherever a spray was so furnished the lice would disappear within a very short time thereafter. Rapidly as the aphids can increase they cannot increase so fast as to get ahead of these syrphus-fly larvæ. The only unfortunate feature in the whole matter is that only the second brood of these larvæ become abundant enough to do any real good, and by the time they are ready to master the lice, the lice have done a very large proportion of their injury, and the crop has been very considerably damaged; yet in many cases, while they do not prevent all damage, they have prevented total failure. A great many

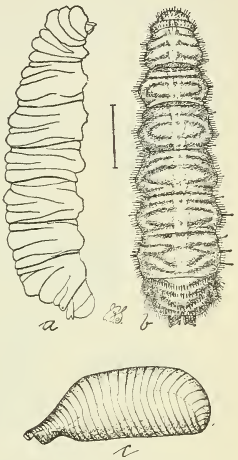


Fig. 73.

Syrphus torvus: *a*, larva, from side, showing the wrinkled appearance; *b*, same, from above; *c*, pupa. (Original.)

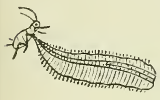


Fig. 74.

Syrphus larva holding up its prey. (After Riley.)

other species that are more or less useful occur, and not all upon the leaves of plants only. One form, *Pipiza radicans,* lives underground, feeding upon the apple root-lice and the grape root-lice, or phylloxera. This family is one of the best friends of the agriculturist and should be known by every farmer, since it contains no species which does him any injury, though some larvæ are said to be pollen-feeders.

Fig. 75.

Syrphus torvus, mature fly. (Original.)

A family which is closely allied to the preceding is the *Conopidæ,* and these resemble quite frequently, in a most remarkable manner, certain species of wasps. They are pretty flies, and are also found upon flowers. The larvæ of the members of this family are parasitic, chiefly upon bumble-bees and wasps, which perhaps accounts in some measure for their resemblance to the latter insects, but they have also been found in the egg-pods of grasshoppers. Specimens of *Conops* have been noticed following a bumble-bee and repeatedly flying against

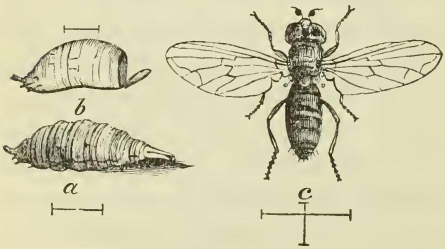


Fig. 76.

The root-louse syrphus-fly, *Pipiza radicans:* *a,* larva or maggot; *b,* puparia; *c,* fly. (After Riley)

it. It is probable that the eggs are thus deposited by the female upon the body of the bee, and, hatching, they burrow in the abdominal cavity and there remain, feeding upon the soft tissues until they have arrived at the period for their transformation, when they escape in the adult form through an opening made between the abdominal rings. Though these insects are parasitic, it is perhaps a question whether they can always be considered beneficial, and they may even be claimed as injurious in some cases, because bumble-bees perform a very important function in the course of nature, the fertilization of some clovers depending upon them in very great part. At all events they cannot be praised as unreservedly as the members of the preceding family, except so far as they infest grasshoppers.

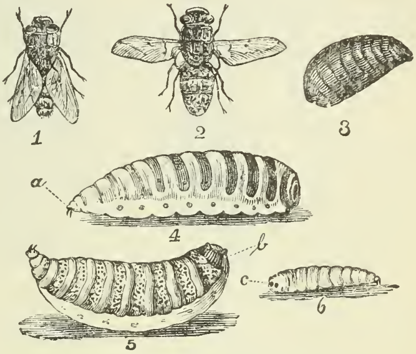


Fig. 77.

Sheep bot-fly, *Œstrus ovis*: *1*, *2*, adult fly; *3*, pupa; *4*, *5*, full-grown larvæ; *6*, young larva. (After Riley.)

In the natural system there follow the "bot-flies," or *Œstridæ*. These are assuredly not beneficial, living in animals of many descriptions, and, among others, infesting farm animals. They are, therefore, to be considered as injurious, and need no further reference here. In order that they may be recognized, a figure of the sheep bot-fly is inserted here.

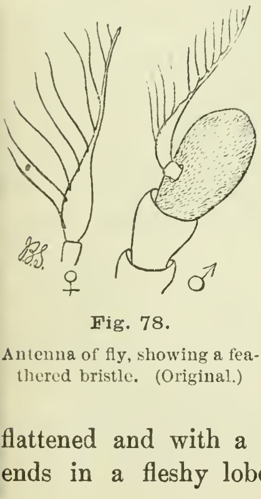


Fig. 78.

Antenna of fly, showing a feathered bristle. (Original.)

There follows now a very large series of flies that may be loosely termed *Muscidæ*, although they comprise really a considerable number of families. The common house-fly and the "blue bottle," or "blow-fly," at once recall the appearance of this family, which is of very great extent. The antennæ are three-jointed, the terminal joint being flattened and with a more or less plumose bristle. The proboscis ends in a fleshy lobe, like that of the blow-fly (Figure 56) in

many instances, but in others the mouth parts are modified for piercing, as in the common cow-fly, or in the horn-fly, which so recently has been troublesome in our State. Perhaps the greater

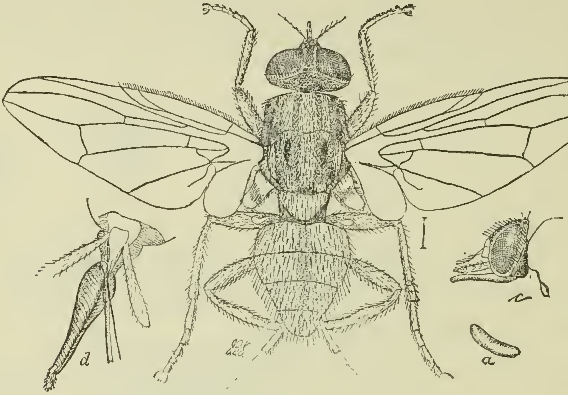


Fig. 79.

Horn-fly, *Hæmatobia serrata:* *a*, egg; *b*, fly; *c*, head from side; *d*, mouth parts. (Original)

part of the insects belonging here are feeders upon decaying animal or vegetable matter, and are maggots *par excellence.* We have, however, in this series a mixture of injurious and beneficial insects, which it is difficult to separate so that they can be recognized by any but the special student. Perhaps this will be a good place to call attention to the fact that flies, after they have once become flies, never grow. There is no relation, direct or indirect, between the large flies that we see sometimes in early spring and the small flies that follow later. From the time that the adult makes its escape from the pupa to the end of its life, it remains of exactly the same size, and never varies one way or the other. I am induced to call attention to this point, because, perhaps, one of the easiest ways to describe flies is by size and general

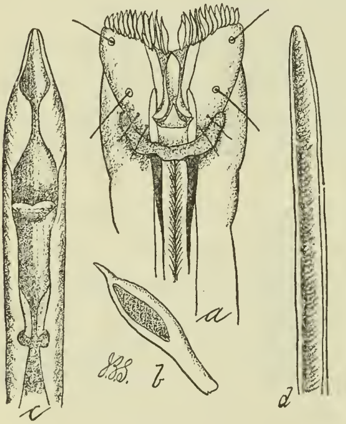


Fig. 80.

Mouth parts of horn-fly: *a*, tip of the sheath; *b*, one of the fleshy processes of same; *c*, lancet guide and piercer; *d*, lancet. Enlarged. (Original.)

color. Large flies, of the size of the blow-fly, or a little smaller, if they are blue or green in color, are generally scavengers, and lay their eggs in decaying matter, vegetable and animal. In so far as they assist in removing such material, they are beneficial, but not in any direct sense from the farmer's standpoint. Some of them may be even classed as injurious, since they occasionally lay their eggs in living animals and even man, where an offensive discharge from the mouth or nose or from sores may attract them, and the maggots may, in some cases, cause a very great deal of trouble. Of such character is the "screw-worm," which, in the South and Southwest, has been a sad pest, but which, though it is common in our own State, has not been troublesome here. Small flies, smaller than the ordinary house-fly, more graceful and slender in general build, with pretty banded or smoky wings, may be generally

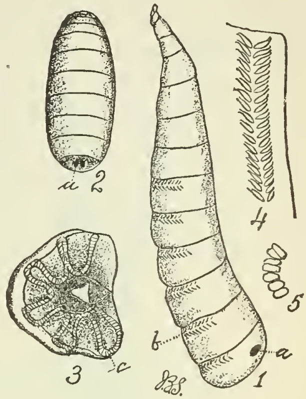


Fig. 81.

1, larva of horn-fly; *2*, pupa; *3*, anal stigmata; *4*, motile processes of larva. (Original.)

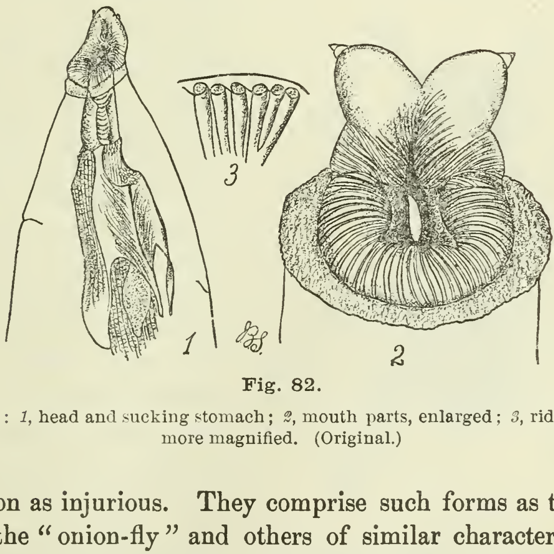


Fig. 82.

Horn-fly larva: *1*, head and sucking stomach; *2*, mouth parts, enlarged; *3*, ridges of same yet more magnified. (Original.)

looked upon as injurious. They comprise such forms as the "apple-maggot," the "onion-fly" and others of similar character. Some of the forms are called "peacock-flies" from the habit they have of

strutting about and elevating their wings as a peacock does its tail. These insects live mainly in fruits or tubers, sometimes laying their eggs in the sound fruit and sometimes at points where it has been injured. The maggots then increase the injury and entirely ruin the specimen.

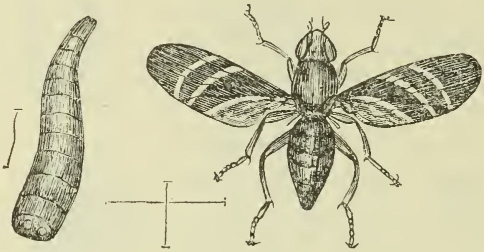


Fig. 83.

Tritoxa flexa, onion-fly. (After Riley.)

Rather large, robust flies, dull ashen gray in color, clothed with stiff bristles or hair, and with spiny legs, larger than the house-fly as a rule, and sometimes even larger than the flesh-fly, are tolerably apt to be beneficial, and include the family *Tachinidæ*. In the entire order there is no group so beneficial to the farmer, and they are almost equal in their importance to the ichneumon-flies belonging to the order *Hymenoptera*. They are usually short, thick-set, of the size already mentioned, and are distinguished from some of the other families by having the bristles of the antennæ entirely bare—that is to say, not clothed with hair. They are usually sober-colored, rarely conspicuous, quick in flying and abrupt in their movements, and frequent flowers and rank vegetation. The larvæ are thick, cylindrical, somewhat flattened

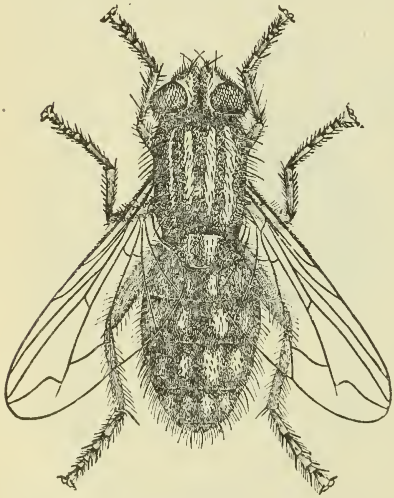


Fig. 84.

The common flesh-fly, *Sarcophaga carnaria*; very greatly enlarged. (From Standard Nat. Hist.)

below the segments, with transverse swellings for locomotion, and either naked or with bands of fine, short bristles. A very large proportion of them are parasitic upon the larvæ of the *Lepidoptera*, but they also infest grasshoppers, crickets, beetles, *Hymenoptera*, and even some crustaceans and turtles. So far as the farmer is concerned, the insects are chiefly useful to him from their habit of preying upon caterpillars, and it is surprising what an enormous number of larvæ are destroyed every year by these flies. Some of our worst pests are infested by them, and their rank as a check to undue increase is extremely high. Their eggs are white, small, elongate-oval, less than one-sixteenth of an inch in length, and as they are laid on the outside

Fig. 85.

Exorista leucaniæ, army-worm tachinid; somewhat enlarged. (After Walsh.)

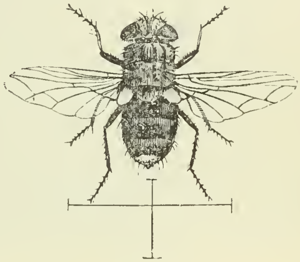


Fig. 86.

Exorista flavicauda, yellow-tailed tachina-fly. (After Riley.)

of the caterpillar are thus readily seen. As a rule the eggs are laid on the back of the larva and close to the head, in such a position that it is absolutely impossible for the caterpillar to get at or to remove them. It is quite a common occurrence to see cutworms with anywhere from one to five or six or more of these white eggs glued to the skin, and every larva so infested is doomed. During the past season, when the "wheat-head army-worm" became so enormously abundant, more than half of the specimens that were sent me contained eggs of tachina-flies. It is rather interesting to watch these flies laying their eggs on the caterpillars. The larvæ seem to realize the fact that they are endangered when they notice the presence of the fly, and will endeavor, by squirming and moving about, to avoid the placing of the egg upon them, but to no purpose. The fly darts upon its prey, the ovipositor slightly extruded, and at a touch the egg is placed. So rapidly is this done that it is difficult to watch the operation, for two or three eggs will be deposited in rapid succession, almost before the

attention can be centered upon the act. When the eggs are laid the fly leaves its victim to search for others, and the caterpillar, after a vain attempt to get rid of the objects which it feels as a burden, soon resumes its feeding. In a short time the larva hatches, makes its way out of the egg and at once pierces the skin and enters the body of its victim. These tachina-flies never give birth to living young, as is the case with many of the forms that feed in decaying matter, but as a rule the eggs hatch very soon after they have been laid. The little footless maggots feed in the body of the caterpillar, avoiding all the vital points, and subsisting rather upon the juices of their host than upon actual tissue. About the time that their host is full grown they have also become of full size and ready to change into pupæ. As soon as this period arrives, when they have nothing more to gain in the way of food, they pay no further attention to the comfort or well-being of the caterpillar in which they feed, but make themselves comfortable, forming the pupa in the body of their host, and in this process kill it. Anywhere from one to a dozen of these larvæ are matured in a single caterpillar of moderate size, and in large caterpillars, like those of some of our native silkworms, or of the large hawk moths, forty to fifty specimens find sufficient nourishment. As a means of checking the increase of certain forms of noxious insects, nothing could be better than these parasites. The drawback, which I have already mentioned, is in the fact that the caterpillars live out their full life and continue their destruction on the farm crops despite the presence of these creatures in their vitals.

Fig. 87.

Belvoisia bifasciata, banded tachina-fly. (After Riley.)

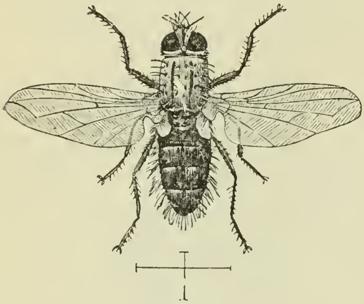


Fig. 88.

Lydella doryphoræ, potato-beetle parasite. (After Riley.)

Another series of flies resembles the house-fly in color and in general appearance, but is very decidedly smaller, and usually as injurious as those previously mentioned were beneficial, although even

here we have some parasitic species. I refer to the family *Anthomyidæ.* I cannot characterize these insects better than by comparing them, as I have done, with the house-fly, and when, as is sometimes the case, they are found in rooms and on windows, they are usually mistaken for the common pest. Many of these forms feed upon vegetation, and preferably upon roots. In this family come those species which are altogether too well known, as "onion maggots," "cabbage maggots," "radish maggots," and others of similar bad reputation. In their larval form they resemble those that feed in decaying matter, and even those that are parasites, and they feed in much the same way, only, instead of attacking living creatures, as a rule they attack living vegetation. They need not be more fully described here, since none of the parasitic species have any value to the farmers of this State.

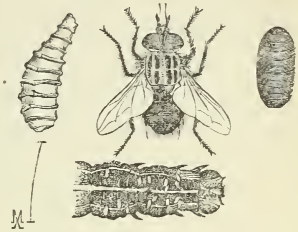


Fig. 89.

Nemoræa leucaniæ: larva, puparium and adult; also forepart of of an army-worm, showing placing of parasitic eggs. (After Comstock.)

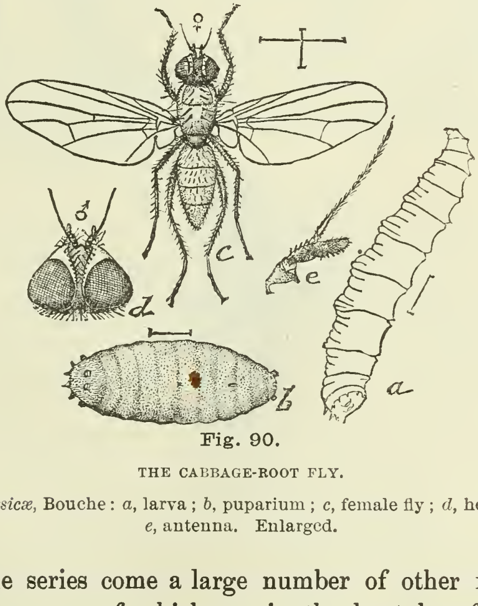


Fig. 90.

THE CABBAGE-ROOT FLY.

Anthomyia brassicæ, Bouche: *a,* larva; *b,* puparium; *c,* female fly; *d,* head of male fly; *e,* antenna. Enlarged.

Next in the series come a large number of other flies, including several families, none of which are in the least beneficial, and most of which are innoxious, though some are positively injurious. Most

of the species are small, half the size of the house-fly, or even less, and a great many of them are prettily colored. As an example of one of the innoxious forms we may name the little pommace-fly, yellow in color, and with very bright red eyes, which is found in

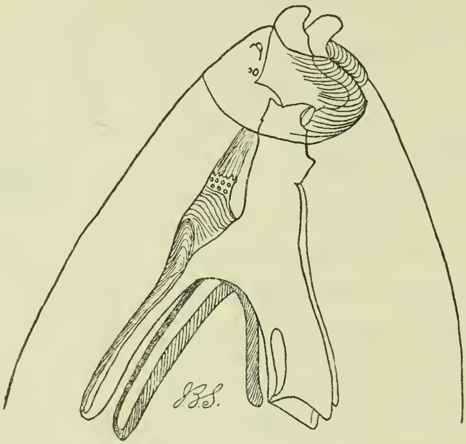


Fig. 91.

Mouth parts of larva of cabbage maggot. (Original.)

such enormous swarms wherever fruit is in a state of fermentation. Where cider is made, thousands of these little flies will gather; where grapes are pressed, swarms are gathered, not only on the skins but in

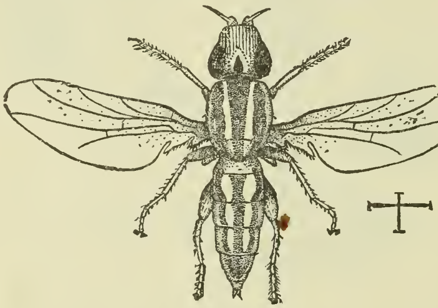


Fig. 92.

Meromyza americana: imago. (After Forbes.)

the fermenting juice. If they are not disturbed, the entire mass of fermenting fruit will soon be filled with little maggots. Others, prettily striped with black and yellow, are more decidedly injurious,

attacking grains, as in the case of the American *Meromyza*, which causes the silver tip in grasses both cultivated and wild.

We have seen that the order *Diptera* contains a very large number of forms that are either beneficial or at least not harmful to the agriculturist, and we have seen that there are, comparatively speaking, only a few which are anything but friendly to him. The figures that are interspersed in the text are intended to give a general idea of the appearance of the different families that have been mentioned, sufficient to enable an intelligent man to make a close guess at those forms that are of importance to him.

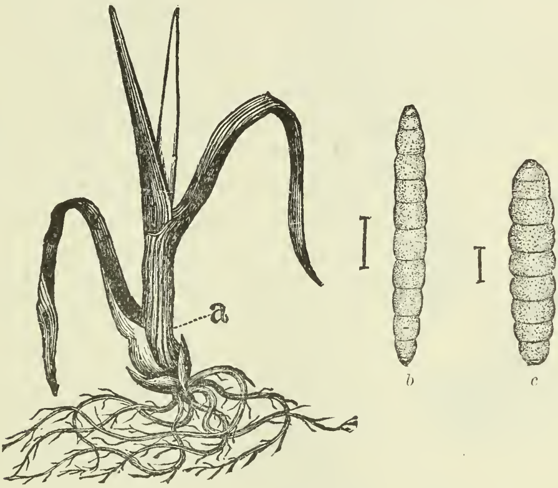


Fig. 93.

Meromyza americana: *a*, location of larva in stem of wheat; *b*, larva; *c*, pupa. (After Fitch.)

The order *Coleoptera*, or beetles, contains a very large number of species, more than ten thousand having been described from the United States alone, and among these we have habits of many different kinds represented. We have feeders upon flesh, feeders upon plants, feeders in wood and feeders in carrion. Some live underground and never come to the surface; some live upon plants in all their stages; some live in water, occasionally spending their entire life under the surface. Whatever their habits, beetles may be always recognized by the horny or chitinous fore wings, forming a shield for the hind wings, which fold under them and are used in flight. The mouth parts are always mandibulate or formed for biting, though sometimes the head

is prolonged into a beak or snout, at the end of which the organs for chewing are very much reduced and sometimes obsolete. The head is usually distinct, and the prothorax is separate, that is, movable upon the other segments, and is alone visible on the upper side. The transformation or metamorphosis is complete; that is, there is a quiescent pupal stage, in which all the members of the future beetle are separately encased. The larvæ differ so greatly that it will be best to speak of them under the family headings. Among such a mass of forms we have, of course, a great many that are of importance to the agriculturist, either as being beneficial or as being injurious to him. It is somewhat easier to recognize friends and foes in this order, from certain structural characters that can be easily observed, and which will largely determine the character of the insects. As we are more particularly concerned with the forms that are beneficial, it will be well to show first how some of those that are not beneficial may be recognized.

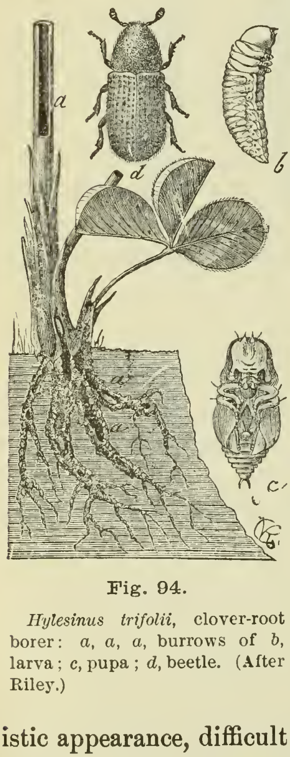


Fig. 94.

Hylesinus trifolii, clover-root borer: *a*, *a*, *a*, burrows of *b*, larva; *c*, pupa; *d*, beetle. (After Riley.)

In the first place none of the snout-beetles or weevils are entitled to be called beneficial insects. While many of them may not be actively injurious yet none of them are actively beneficial. Every insect, therefore, belonging to this order, which is furnished with a snout or beak, whether it be long or short, should be looked upon with suspicion and is never a friend.

Belonging to the snout-beetles, yet with only a very short beak or none at all, are the Scolytids, or bark-beetles, living usually, though by no means always, under the bark of trees, where they or their larvæ make characteristic galleries or borings, emerging from the bark through small, round holes, resembling shot-holes. Very frequently the wood itself is penetrated, and more rarely the insects are root-borers. The beetles are usually small, cylindrical, rather slender and obtusely terminated before and behind, and have a characteristic appearance, difficult to mistake. It is well illustrated in Figure 94, and of course all of these bark beetles are injurious.

Another series of beetles which contains only injurious or at best innoxious forms, is the *Lamellicornia*. These obtain their name from the peculiarity of the structure of their antennæ or feelers, which terminate in a leaf-like club. This club varies somewhat in size, but is always easily perceptible, and is built as is shown in the accompanying figure. None of the insects are small in size, and some of them are very large. They contain such insects as the "May-beetle," the "rosechafer," and "grubs," and all have approximately the same form, which is well illustrated in the accompanying figure of one of the common May-beetles. A great many of these white-grubs spend all their time underground, feeding upon the roots of plants, and often upon those of cultivated plants. One entire group, however, of quite large extent, feeds rather in decaying vegetable and excrementitious matter, and to this series belong the so-called "tumble bugs" or "pill bugs." These insects derive their name from their habit of forming little balls or pellets of dung, in which they lay their eggs. These little balls or pellets are buried underground a longer or shorter distance, and in them the larvæ develop. Some of the larger forms will roll these pellets for some distance from the place at which they were formed, and they are quite frequently seen on roads, and are well known to almost every farmer's boy who has paid the least attention to what passes before his eyes. These insects of course serve a useful purpose, but can hardly be

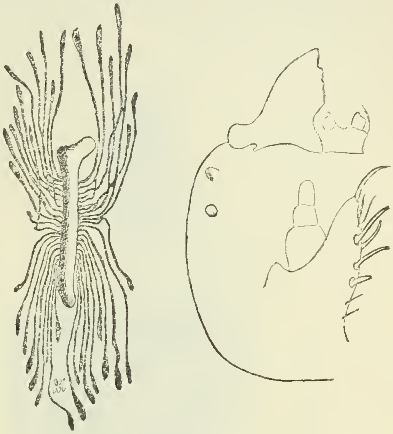


Fig. 95.

Burrow of the hickory-bark borer, *Chramesus icoriæ*, and mouth structures of the larva. (Original.)

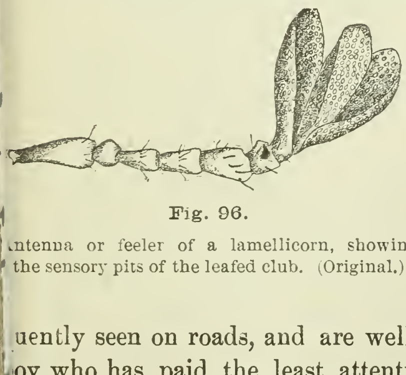


Fig. 96.

Antenna or feeler of a lamellicorn, showing the sensory pits of the leafed club. (Original.)

called beneficial, and they are in company with so many forms that are actively injurious that they do not serve to redeem the entire group to which they belong, from condemnation. No insect that has a lamellate or leaf-shaped antennal club can be considered as friendly to the farmer, and should always be looked upon with suspicion.

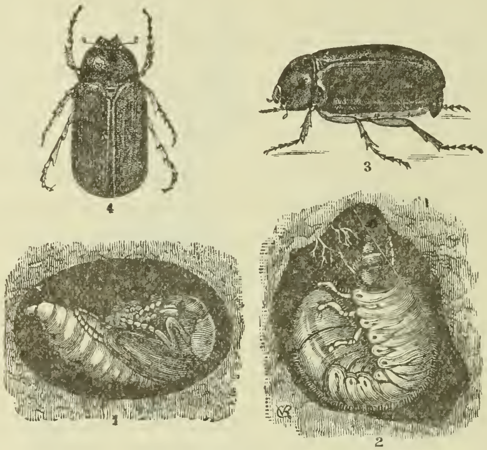


Fig. 97.

The common May-beetle, *Lachnosterna fusca:* 1, the pupa; 2, the larva or white-grub in its ground cell; 3 and 4, the beetle, side and dorsal views. (After Riley.)

The character of the tarsi, or feet, is one that is used very largely in separating beetles and in dividing them into great series, and this will serve us somewhat conveniently for separating off another large lot of insects that are essentially feeders upon vegetation. The legs of all insects are formed approximately as shown in the figure herewith given, in which the parts are named. We have first, at the extreme base, the coxa, which joins the rest of the leg to the body, and this is rarely a prominent feature. Following this comes the femur, or thigh, which is usually the stoutest part of the entire leg, and contains the muscular structures, or most of them, at least, and connecting this with the coxa is usually another

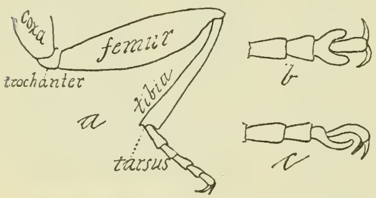


Fig. 98.

a, illustrates a normal insect leg with all the parts named, the tarsus five-jointed; *b*, four-jointed tarsus, third joint lobed; *c*, same from side. (Original.)

small piece, the trochanter; next, we have the tibia, or shank, and, finally, we have the tarsus, or foot, which is composed of a number of joints, varying in the beetles from three to five. In a large series of beetles we find that this tarsus is composed of four joints, apparently, and that the third joint is lobed or divided into two parts, from the center of which a claw joint arises. The figure herewith given illustrates a tarsus built on that style, and all the insects with feet of this description can be considered as enemies, or, at least, no

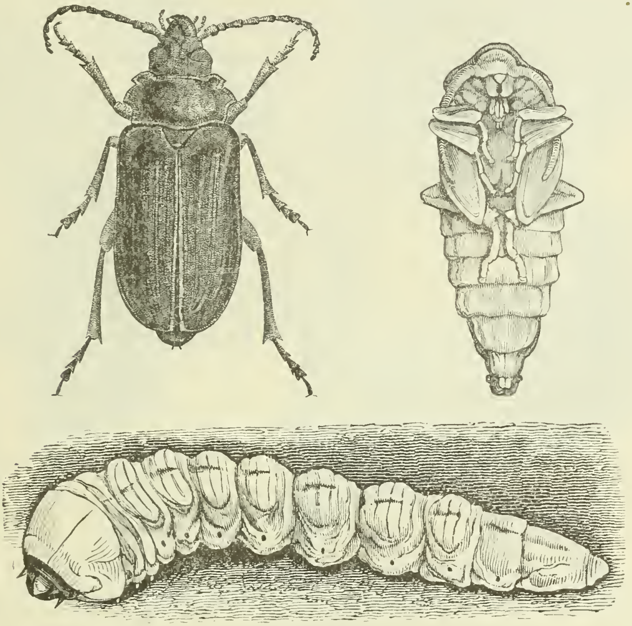


Fig. 99.

The giant root-borer of grape, blackberry, etc., *Prionus laticollis:* larva, pupa and imago. (After Riley.)

active friends of the farmer. The very great majority of them feed upon plant tissue, and none of them, so far as I am able to recall, are either parasites or predaceous. Two large families are so characterized, the *Chrysomelidæ* and the *Cerambycidæ*.

The *Cerambycidæ* are rather readily recognized by their oblong, often cylindrical bodies, the long, filiform or thread-like antennæ, which are rarely shorter than the body and sometimes more than

twice as long, and by the powerful in-curved mandibles. Their long feelers have led to their being called longicorns and capricorn-beetles. The larvæ are long, fleshy, slightly flattened or cylindrical, often footless, whitish grubs, with very convex rings or segments. The head is very small, but is armed with strong, gouge-like mandibles, adapted for boring like an auger in the hardest woods. They live, generally, in the woody tissue of plants, and almost all varieties of trees are attacked by them. Not only trees, but many kinds of shrubs and cultivated vines and plants are infested by some of the species. Blackberries, currants, raspberries, grapes and plants of that description are all attacked by these long-horned beetles. Occasionally, herbaceous plants, like milkweed, for instance, are infested; but not a great many species have this habit. Most of them, like the "apple-borer,"

Fig. 100.

Apple borer, *Saperda candida*: *a*, larva; *b*, pupa; *c*, beetle.

live in wood and frequently do a great deal of mischief. Quite usually, the first body segments are larger than any of the others, and the swelling is sometimes so abrupt that it looks as if it really formed part of the head of the insect. None of the members of this family can, by any possibility, be considered as beneficial.

The *Chrysomelidæ* are leaf-feeding beetles, and contain only injurious forms. To this family belong the Colorado potato-beetle, our various flea-beetles, the elm-leaf beetle, the striped melon-beetle, the "tortoise-beetles" and others with similar habits, and the insects mentioned will serve also to give an idea of the variation in form which is found within this family. In some cases it becomes rather difficult to distinguish members of this family from that immediately preceding, but such forms are rarely met with and may be left out of consideration here, entirely. As a rule the beetles are oval or oblong, often

very thick and convex, with short antennæ, rounded, prominent eyes, and a variable thorax. Sometimes, as in the flea-beetles, the posterior legs are very much developed and formed for leaping. The jaws are usually rather small, and are more or less scoop-shaped and formed for masticating leaf tissue. The larvæ are short, rounded, cylindrical or flattened, sometimes very much elongated and slender,

Fig. 101.

Elm-leaf beetle: *a*, eggs; *b*, larvæ: *c*, adult; *e*, eggs, enlarged; *f*, sculpture of eggs; *g*, larva, enlarged; *h*, side view of greatly-enlarged segment of larva; *i*, dorsal view of same; *j*, pupa, enlarged; *k*, beetle, enlarged; *l*, portion of elytron of beetle, greatly enlarged. (After Riley.)

generally of a soft consistency, often gaily colored, sometimes beset with thick, flattened tubercles or branching spines, and nearly always with well-developed feet. In the larvæ of the potato-beetle and the asparagus-beetle we have modifications of one type which are familiar to most farmers. In the elm-leaf beetle, which is also well known, we find another somewhat modified form, while in the larvæ of the striped melon-beetle we find a slender type resembling in miniature a wireworm, except that the texture of the body is soft. A some-

what interesting form is that found in the sweet potato "golden-beetles," which are oval and flattened and with curious anal processes. Quite usually the larvæ feed freely on the outside of the leaves, but

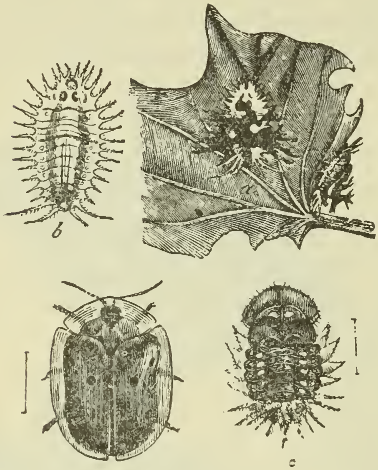


Fig. 102.

Sweet-potato beetle: *a*, larvæ on leaf; *b*, larva; *c*, pupa; *d*, beetle. *b*, *c*, *d*, enlarged.

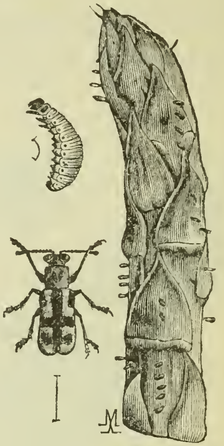


Fig. 103.

Asparagus-beetle: eggs, larva, adult. (After Comstock.)

not unusually they feed underground on the roots of plants, and sometimes, as in the case of some flea-beetles, they feed within the tissue of the leaf and are miners.

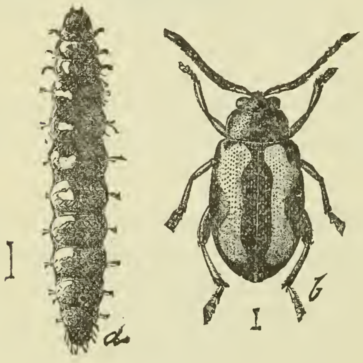


Fig. 104.

Striped flea-beetle, *Phyllotreta vittata*: *a*, larva; *b*, adult. Both greatly enlarged. (After Riley.)

Another set of beetles that we can separate off without very much trouble is the *Elateridæ* or "snapping-beetles," or "click-beetles," as they are often called. In these insects the antennæ are serrated or saw-toothed, and the head is small and retracted. The tarsi or feet are five-jointed in this family, and none of the joints are lobed. It may be said in a general way here, that this combination of a five-jointed tarsus and a serrated or toothed antenna, when found in a beetle, indicates that the species is

one which should be regarded with suspicion. It is usually a feeder on vegetation, and not often to be classed as friendly. There are some exceptions, however, which are hereafter mentioned. The prothorax in these snapping-beetles is loosely articulated to the rest of the body, and on the under side or breast there is a curved process which extends backward and fits into a groove between the second pair of legs in such a way as to enable the species to leap in the air by a sudden jerking movement, which has been described as follows: "They possess the singular power of springing in the air when placed on the back. This is effected by extending the prothorax so as to bring the prosternal spine to the anterior part of the mesosternal cavity, then suddenly relaxing the muscles so that the spine descends violently into the cavity. The force given by this sudden movement causes the base of the elytra to strike the supporting surface and by their elasticity the whole body is propelled upward." The beetles are thus easily recognized, and the larvæ are no less marked. They are generally known by the name of wireworms, and are vegetable feeders, living on the

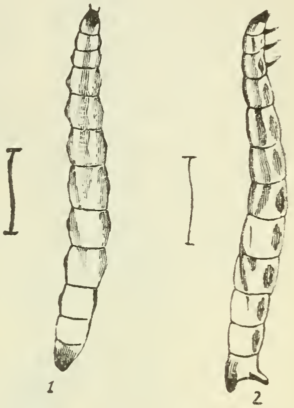


Fig. 105.

Diabrotica vittata, larva of striped melon-beetle: *1*, from above; *2*, from side. Enlarged.

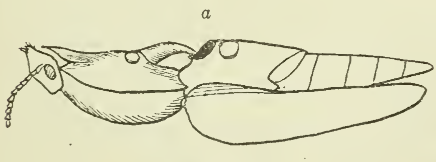


Fig. 106.

Snapping-beetle, showing the prosternal spine at *a*. (Original.)

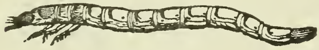


Fig. 107.

Wireworm, natural size.

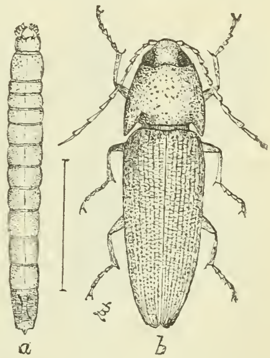


Fig. 108.

Common snapping-beetle, *Melanotus communis*: *a*, larva; *b*, beetle. (From Bruner.)

roots of grasses, corn, potatoes, turnips and other field crops and garden vegetables. The eggs are laid, preferably, in pastures and fallow ground where the surface is undisturbed, or in the vicinity of or in rotten wood, in which some of the species feed. The larvæ of many species live several years. They are very long, cylindrical and hard-bodied, whence their name "wireworm," and generally pale yellow or yellowish red in color. They have six distinct true legs and a small anal prop leg. The body is flattened somewhat towards the head and tail. These insects are very well and not too favorably known to the farmers, and I have never heard of their being regarded in the light of friends.

Another family which affords the same structural combination of serrated antennæ and five-jointed tarsi is the *Buprestidæ*, for which we have no common name. The beetles somewhat resemble those of the preceding family, but have not the power of springing, and they are generally shorter and broader. Most of them have the outer body very hard and tough, and usually the colors are metallic, often with a golden or bronze luster. Occasionally the species are more cylindrical, as with the red-necked blackberry-borer, which will serve fairly well as the type of one section of this family. The more usual form, however, is that which we find in the flat-headed apple-borer, a picture of which is herewith given. The larvæ of these insects are wood-feeders, as a rule, using this term in a somewhat loose way, and they are generally somewhat flattened, the segments well marked, the body much elongated, the head small, with powerful jaws, the first body segments much enlarged. They have somewhat the form of the larvæ of the long-horned beetles or *Cerambycidæ*, but can always be distinguished from them by their more flattened body and flat head. The larvæ more generally feed in the sap wood, forming channels under the bark, and do not so generally bore into the heart of the tree itself, as is the case with the other family. In some cases the larvæ of the smaller species are leaf-miners, living in the tissue between the upper and under surfaces.

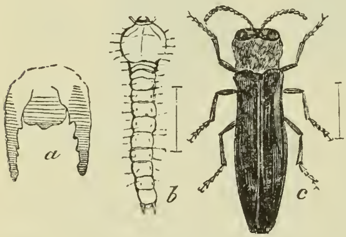


Fig. 109.

AGRILUS RUFICOLLIS, Fabr.

Larva and beetle, enlarged. (After Riley)

We have now separated off, in a general sort of way, those families and series which contain most of our injurious and few or none of our beneficial species among the beetles, and they form a large part of

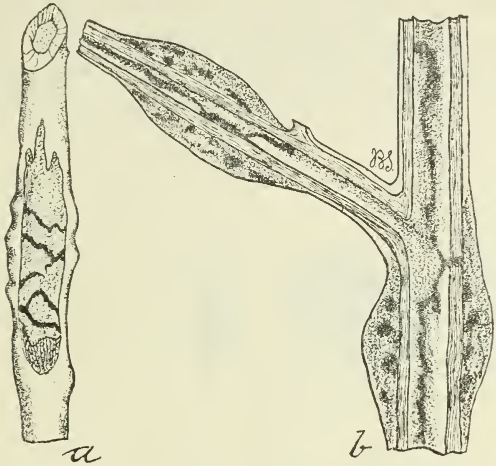


Fig. 110.

Gall of red-necked Blackberry borer: *a*, section through galls on main cane and lateral, showing the track of larva through the bark and pith, and pupal cell; *b*, tracks of young larvæ. (Original.)

the entire order; but there are yet a greater number of families that are either indifferent to the farmer or contain only a few that are sometimes troublesome or that are positively beneficial. Following out the plan of separating off those forms that are most easily recognized, we next come to what are usually called "fire-flies" or "lightning-bugs." The appearance of these insects is quite well known to almost every observer. They are generally elongated, rather slender insects, and the wing covers, indeed the entire outer coverings of the body are soft, never hard as in the preceding families. The antennæ are serrated or saw-toothed, and the tarsi are five-jointed, coming under the general condemnation previously made; but they differ, so far as tarsal structure is concerned, from the families last spoken of

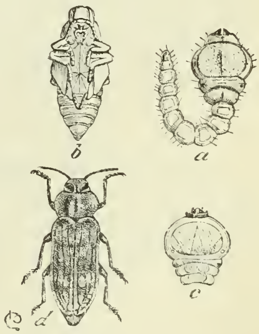


Fig. 111.

Chrysobothris femorata: *a*, the flat-headed apple borer; *b*, pupa; *c*, under side of head and thoracic rings; *d*, beetle. (After Riley.)

by having the fourth joint lobed somewhat similar to the lobe of the third joint in the *Cerambycidæ.* The curious feature in this family, from which it has received its common name, is the power that many of them have of emitting a flash of phosphorescent light at the will of the insect. These light-bearing organs are usually on the last segments of the abdomen, and when not in active use appear of a sulphur-yellowish color. In some cases, however, the larvæ, and the females

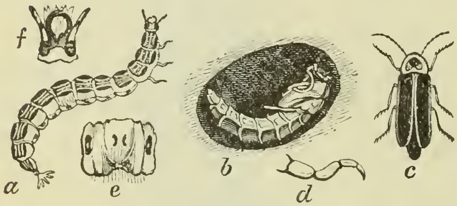


Fig. 112.

Photinus pyralis, fire-fly: *a*, larva; *b*, pupa; *c*, beetle; *d*, *e*, *f*, parts of larva. (After Riley.)

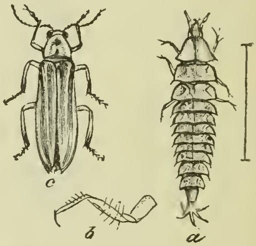


Fig. 113.

Photuris pennsylvanicus, fire-fly: *a*, larva; *b*, its leg; *c*, beetle. (After Riley.)

where they do not obtain wings, have luminous spots along the sides as well, and such forms, when they are noticed in the grass, are called "glow-worms." The larvæ are rather long, flattened, blackish, with the edges of the segments well marked, and many of them live on snails or other creatures of that character, though probably attacking insect larvæ as well in some cases. Thus, while they are not injurious they are not strictly beneficial and they need not be regarded by the farmer as of particular interest to him.

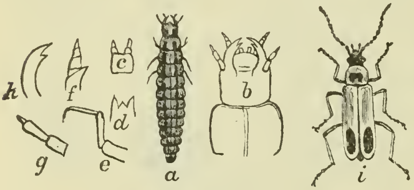


Fig. 114.

Chauliognathus pennsylvanicus: *a*, larva, natural size; *b*, head and first segment of same, enlarged; *c*, labium; *d*, labrum; *e*, leg; *f*, left maxilla; *g*, antenna; *h*, left mandible; *i*, imago. (After Riley.)

A nearly allied family is the *Telephoridæ*, which, in general appearance and in texture, resembles the fire-flies. The head, however, is more prominent and larger, the eyes distinct and globose and the thorax parallel. None of these have the power of emitting light, although, as has been said, they resemble the fire-

flies. Among the most common species is the so-called "soldier-beetle," *Chauliognathus,* which is very abundant on flowers. There are really two species of these soldier-beetles, one appearing in spring and another in fall; but they resemble each other so much in appearance that for all practical purposes they may be considered as one. The larva of this insect has, in a general way, the shape of the fire-fly larva, but is somewhat more slender. Its habits are also predaceous; but it feeds upon insect larvæ which it finds in the ground, and it has been noticed devouring that of the plum-curculio, which at once stamps it as a beneficial insect. This forms an exception to the rule previously mentioned, and the soldier-beetles and their larvæ must be considered as friends. In the accompanying figure, the appearance of both the larva and the beetle is shown. The larvæ live only on the ground; the beetles, on the contrary, frequent flowers. The form that appears in spring can be found on blossoms of all kinds; the form that appears in fall favors golden-rod, where it can often be seen in very large numbers. Common as these insects are, they are, undoubtedly, an important factor in nature's battery for checking the increase of species that feed upon vegetation, and they should be recognized as friends. Other species of the *Telephoridæ* have similar habits; but they are rarely common, and mostly frequent wood-lands, finding their prey in species other than such as are injurious to the farmer.

Another small family that belongs close to this place is the *Malachidæ.* The insects somewhat resemble those of the previous family, in so far that the body texture is soft and the wing covers are not hardened. They are, however, very much shorter and the body is decidedly broader. The feelers are also short and a little enlarged toward the tip; in the males, often curiously knotted in the middle. They are found on flowers, sometimes not uncommonly, and they feed on other insects and insect eggs, probably doing a great deal of good in that way. The larvæ of only a few species are known, and so far as we do know anything of them, they are also predaceous, and feed on quite a variety of other insects.

The family *Cleridæ,* comprising the "flower-beetles," belongs to this same series, but is distinguished in the classification by the fact that the tarsi have the joints furnished beneath with membraneous appendages. The more common species are not unlike the members of the previous family, but they are throughout of a firmer consist-

ency, never soft or with shortened wings. The head is generally large, the eyes prominent, the antennæ being of good size and quite frequently with a more or less distinct club at the tip. The beetles are often prettily banded, red and black, yellow and blue, and the colors are sometimes strongly contrasting, making the insects rather conspicuous on the flowers that they frequent. While most of the species may be found upon flowers at some time—and many of them are rarely found elsewhere—yet they do not breed upon flowers, and the larvæ are carnivorous and sometimes partly parasitic. In a very few instances the larvæ feed upon dead animal matter; but these cases are exceptional. In form, the larvæ are rather elongated and slender, somewhat depressed or flattened above, the segments well marked, the head quite prominent and the end of the body frequently furnished with anal forceps. The habits of these larvæ differ quite widely; but there are two main lines along which they work. One series of them infests the nests of bees, the eggs being laid by the beetles in or near the nests themselves. The larva, when hatched, first devours the grub of the bee in the cell in which it is born, and then proceeds from cell to cell, preying upon the inhabitant of each until arrived at maturity. It is in this situation, also, that it undergoes its changes in a small cocoon which it has previously constructed, making its escape from the nest in the beetle state when the hardness of its covering sufficiently defends it from the sting of the bees. Another series lives in the galleries of wood-boring beetles, and more particularly those of the scolytids, which make the peculiar and sometimes very complex galleries under the bark of trees, and clerid larvæ are really the most important checks to the ravages of these bark-boring beetles. The shape of the clerid larva is such that it is able to work its way along the narrow passages made by the borers, and there it devours the eggs where such are in the burrows, or, if they have already hatched, the young larvæ, and in fact the larvæ of any stage, are welcome morsels. It

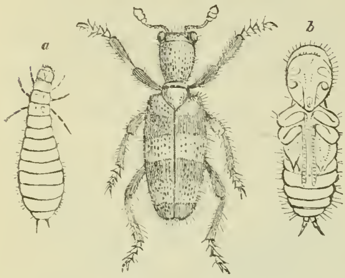


Fig. 115.

Bee-devouring flower-beetle, *Clerus apiarius:* a, its larva; b, pupa Enlarged. (From "Packard's Guide.")

is one of these species, *Clerus formicarius*, that is supposed to keep in check the destructive bark-boring beetles of Europe and to prevent serious injury by them. Our own species are known to have similar habits, and particularly *Clerus nigripes*, but it has been proved positively that under the circumstances as they exist in our country our species are not able to keep down the bark-borers within what may be considered reasonable limits. It has been therefore attempted to introduce the European species in this country, and the Entomologist of the Virginia Experiment Station has imported a very large number of specimens in all stages, which have been turned loose in the forests that have suffered so seriously of late years from some of the bark-borers. The experiment is a very interesting one and offers some chance of success, unless the same causes that operate to prevent a sufficient increase of our own species also prevent the increase of these imported forms, which would be thus an assistance to our own species without accomplishing entirely the result hoped for. One thing must be taken into consideration in estimating the value of this insect, *Clerus formicarius*, in Europe, and that is that their methods of forestry are such that the bark-boring beetles have at best a difficult task to get along. Dead and dying timber is felled and removed; no fallen branches are allowed on the ground, and stumps are taken out before they can become infested by the bark-borers. Man here does his best to prevent and check the increase of the injurious forms, and those species that feed upon them have a comparatively easy task in finding the few burrows that escape, and in destroying the larvæ. This makes bark-borers rare, comparatively speaking, and therefore little or no injury is done by them. In our own country, matters are unfortunately in quite a different state. Nothing like a science of forestry is practiced in most localities; dead trees are found everywhere; sick and dying trunks are left unregarded; others are felled, and stumps are allowed to remain in the ground until they rot; branches that are not needed are left where they have been lopped off; in fact, every possible opportunity is given the injurious species, to continue their kind, and it need scarcely be said that they take advantage of the opportunities offered them. This enables them to increase at an unusual rate, and when they become so abundant that dead and dying wood fails them they attack that which is living, and frequently acres upon acres are ruined. Now in cases of that kind the *Cleridæ*, however active they may be, are really

helpless, because they cannot increase with sufficient rapidity. There is only one brood of them in the course of the year, and the insects are not very prolific; that is to say, the female does not lay a large number of eggs. They therefore increase much more slowly than do the insects upon which they feed, and though they might in the event conquer them, yet it would not be until the bark-beetles themselves were running out of food, and their increase was checked by natural causes. Useful as these clerids undoubtedly are, yet they have no very high value to the farmer in this State, since they do not feed upon any of the pests that infest his field crops.

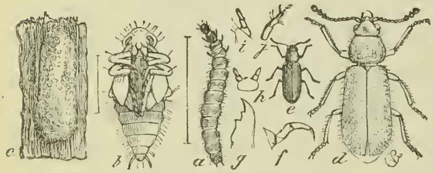


Fig. 116.

Red-legged ham-beetle, *Corynetes rufipes*: *a*, larva; *b*, pupa; *c*, cocoon; *d*, *e*, beetle, enlarged and natural size; *f* to *j*, structural details. (After Riley.)

One little group of this family is quite unlike any of the others in appearance and habits, and feeds upon dead and dying animal matter, often attacking provisions, and of this type the red-legged ham-beetle, *Corynetes rufipes*, is a good example.

There is one more family of insects in which the antennæ are serrated or saw-toothed which it may be advisable to mention, and that

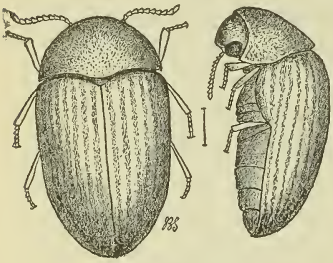


Fig. 117.

Lasioderma serricorne, "cigarette-beetle." (Original.)

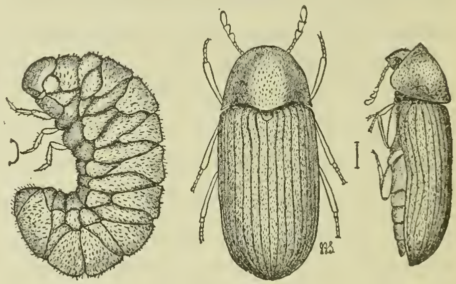


Fig. 118.

Larva and beetle of "death-watch," *Sitodrepa panicea*. (Original.)

is the *Ptinidæ*. These are all small, and sometimes very small insects, often of odd shapes, and most of them feed both in the larval and beetle stage on dead or dying animal and vegetable matter. In some cases, however, living vegetation is also attacked, and none of

the species can be considered in any sense of the word as beneficial. It is the beetles belonging to this family that we find sometimes in stored vegetable matter, and occasionally boring in our furniture, and particularly in rattan or willow ware. A well-known type is the tobacco-beetle, or "cigarette-beetle," on the one hand, and the "death-watch" on the other. This "death-watch," being so called from the habit it has of causing a ticking sound by striking its head or thorax against the wood in which it feeds, causing a sound like the tick of a

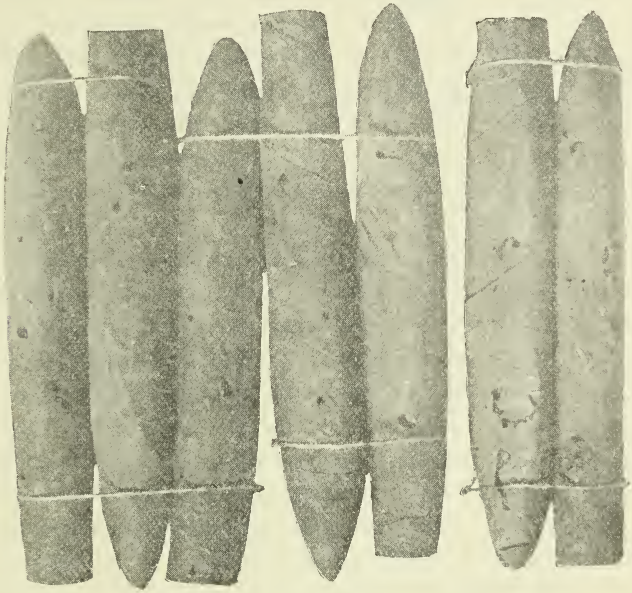


Fig. 119.

Work of tobacco-beetle in cigars. (From a photograph)

watch. When heard in old houses, superstitious people have believed that this is a sign to announce the death of those who hear it. As a matter of fact, it is only the call of the insect to its mate. The larvæ of these insects have somewhat the appearance of minute white grubs, and the appearance of some of the forms is shown in the figures given herewith. As the family contains no beneficial insects, it need not be considered further just at present.

In the great series of beetles which have the antennæ terminated by a more or less distinct club we have a very large variety of forms, with an equally large variety of habits, and some of these are bene-

ficial, a few are injurious, while the most of them are indifferent; that is to say, neither advantageous, nor on the other hand troublesome. In fact it may be said that there are no species in this series which are seriously injurious to growing vegetation, although many of them are troublesome to stored products. On the other hand, some of our most active beneficial insects belong to this series, and in this instance I will first mention those forms that are beneficial, then those that are more or less troublesome, leaving it to be inferred that all the forms that are not specially mentioned are indifferent.

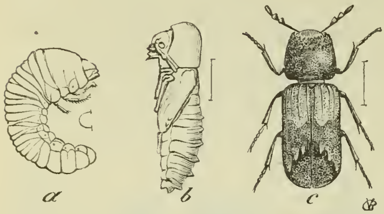


Fig. 120.

Red-shouldered sinoxylon, *Sinoxylon basillare: a*, larva; *b*, pupa; *c*, imago. (After Riley.)

First in the series are the *Staphylinidæ*, or "rove-beetles." They are easily recognized by their long, linear, black or brown bodies, with remarkably short elytra or wing covers, and seven or eight visible horny abdominal segments. Though sometimes an inch in length, they are more commonly minute, inhabiting wet places under stones, manure heaps, fungi, moss, under the bark or leaves of trees, or sometimes in the soil itself, apparently without direct shelter. Quite a number inhabit ants' nests, and some species are never found except in such places. The larvæ closely resemble the beetles, being narrow, the segments of very equal size, the terminal ring forming a long prop leg, but of course there are no traces of wings. The larvæ are found in much the same positions that we find the beetles, and have very similar habits. While the vast majority of the species undoubtedly feed upon dying or decaying vegetable matter, including in that term excrement and fungi, yet some of them are undoubtedly carnivorous, and feed upon quite a variety of insects that they find in the ground. Members of this family are never injurious to crops in our State, and where they are not directly beneficial by feeding upon the enemies of the farmer, they are almost all indirectly

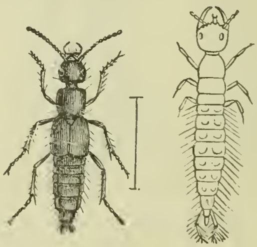


Fig. 121.

Rove-beetle and larva. (After Riley.)

beneficial by assisting in removing decaying matter, sometimes animal as well as vegetable, and in preparing it for assimilation by the plants. No beetles, therefore, that answer to the description above given should be interfered with, nor should they be suspected of injury.

The next family that requires consideration is the *Coccinellidæ*, or "lady-birds," as the insects are generally called. The characteristic form of these insects is well known. They are usually very convex, sometimes almost hemispherical, generally red or yellow, with round or ovate black spots, but sometimes black, with or without yellow or red spots. The antennæ are short, as are also the legs, and the insects move about only slowly. The eggs are yellow, long and oval, and are laid in patches on the under side of leaves, generally those that are infested by plant lice. The larvæ are rather long, oval, soft-bodied, and pointed behind. They are often gaily colored, black, brown or blue, with contrasting yellow or white or red spots or blotches, frequently beset with tubercles or spines. When changing to a pupa the larva attaches itself by the end of the body to a leaf or twig, and either throws off the larval skin, which remains around the tail, or the old dried skin is retained, loosely folded about the pupa as a protector. With one exception, the species of the family that occur in our State feed, both in the larval and adult stages, upon plant lice, and are thus of the highest possible importance to the agriculturist. In order that the species may be recognized by the farmer, a somewhat more full account will be given of these insects than has been given of any of the previous series.

In the typical genus, *Coccinella*, we have forms that are almost hemispherical, and one of the most common as well as the most useful of our species is the *C. 9-notata* or the "nine-spotted lady-bird." This is nearly one-quarter of an inch in length, although many specimens are decidedly smaller, has a black thorax, margined in front with white or yellowish, and has the wing covers yellow or orange, with five black spots on each. One of the spots, however, is exactly on the line where the two wing-covers meet, so when they are closed it appears as a single spot only, and we have therefore nine spots on the wing-covers. This insect is found everywhere, and feeds on almost all kinds of plant lice. It is really the most general feeder in this respect that we have, and it is correspondingly useful. I may say, indeed, that it is the most useful of all the lady-birds in this State, and I have found it feeding upon almost all the species of plant lice

that infest cultivated plants. Its larva agrees in general shape with the figure that is herewith given, and is dark in color, very little relieved by bluish and orange spots. In fact so marked is the general dark color that the larvæ are locally known as "niggers." It is not at all unusual for me to receive these larvæ as the parents of the plant lice, and very few farmers recognize them as their best and most active friends. The advantage of this insect over the many parasites that infest plant lice is that when a specimen is seized its life is ended, and it does no further feeding. It is quite remarkable what a great number of aphids a single one of these larvæ is able to devour, and they seem to be constantly hungry and constantly feeding. I have seen two of them, on a head of wheat, clear off, in the course of twenty-four hours, every solitary louse to be found on it, and in some respects they exercise a rather nice discrimination, for I have noticed that they will not attack lice that have been parasitized, and in which the parasite is full grown. Thus they permit the development of at least a portion of the parasites, while they themselves destroy an astonishing number of these enemies of the farmer. The insects have the further advantage of several broods in the course of the year—how many I cannot say, but they certainly seem to be breeding throughout the entire season, and eggs, larvæ and imagos may be found during almost the entire summer. This enables them to increase at quite a rapid rate when food is abundant, and, usually after midsummer, they become numerous enough to get the better of any lice that they are feeding upon. Unfortunately the larvæ of the lady-birds are themselves subject to parasitic attack, and we frequently find full-grown larvæ which had apparently been ready to pupate, fastened by the tail, but with an ugly hole in the side which showed where the parasite had emerged. The insects pass the winter in the beetle state, and this season is very hard on them, by far the greater number dying either from cold or from other causes of which we know little or nothing, so that comparatively only a few specimens may be found to continue the species in the spring. It has been sug-

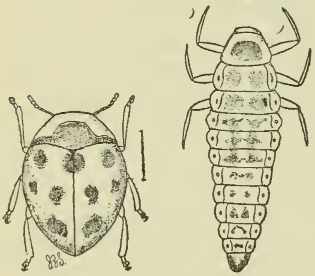


Fig. 122.

Nine-spotted lady-bird, *Coccinella novem-notata*, and larva, enlarged. (Original.)

gested, by others as well as myself, that possibly some advantage might be derived from collecting a number of these insects in the latter part of the summer, when they are very abundant, and keeping them at an even temperature during the winter. We might then be able to turn them loose in the spring, getting in this wise a very large proportion of insects safely through the dangerous season, and giving them a good start in the spring. No direct experiments have been made to my knowledge to prove or disprove the feasibility of this proceeding, but it is at all events worthy of trial and might possibly result beneficially.

A much smaller insect, although of very much the same shape and belonging to the same genus, is the *C. sanguinea*, which is easily distinguished from the preceding, not only by its size but is unlike all

Fig. 123.

Cycloneda sanguinea: larva, pupa, imago. Enlarged. (After Comstock)

others of our species in that it has the wing covers varying from yellow to blood red, without marks of any kind. This is also an extremely useful form, though it is decidedly less abundant than the other, and is not nearly so general a feeder. Its larva, however, is very commonly found among colonies of plant lice and is a worthy assistant to the species previously mentioned. Its habits are so like those previously described that nothing further need be said on this head.

A nearly-allied species to the last, but belonging to the genus *Adalia*, is the two-spotted lady-bird, *A. bipunctata*. This is a little larger and a little more oval in outline than the preceding, with the same general color appearance, but with one black spot on the middle of each wing cover, and from this its name, the "two-spotted lady-bird," is derived. This is found everywhere, and it is the species

that is most usual in garden plots, often entering the houses and feeding upon the plant lice found on potted plants in windows and rooms. Perhaps this little creature is the best known of the lady-birds to the ordinary observer. It is not so effective in the field, however, as the species previously mentioned, though it does its share in the good work, to the best of its ability.

We have several species belonging to the genus *Hippodamia* which are distinguished by their more elongated, oval outline, and somewhat less convex appearance. Our most common form is the *H. convergens*, or convergent lady-bird. This has a black thorax with the front and sides white-margined and two little white marks converging posteriorly on the disk. On each wing-cover there are six small black dots, and there is a seventh on the edge where the elytra join, making it appear as a single spot when the wings are closed. There are thus, apparently, thirteen small black dots on the wing-covers, which otherwise are orange in color. This makes the species an easily-recognized one, and it also is abundant on all sorts of field plants, feeding upon the aphids. It is especially abundant on melons and on other allied plants, and does yeoman duty in lessening the number of melon lice. A very worthy associate is the glacial lady-bird, *H. glacialis*. This has a thorax very like the preceding, but the wing-covers have a broad band posteriorly, a large black spot near the apex of the wing-covers and often a small black dot on the shoulders. It is also quite considerably larger than its ally, but has exactly the same habits and is also one of the common species feeding upon the melon louse.

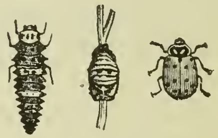


Fig. 124.

Convergent lady-bird, *Hippodamia convergens:* larva, pupa and adult. (After Riley.)

Fig. 125.

The glacial lady-bird, *Hippodamia glacialis.* (After Riley.)

Another species belonging to a very closely-allied genus is the *Megilla maculata*, which is more slender than either of the species heretofore mentioned, and has the thorax and wing-covers a bright but deep red, verging towards carmine. On the thorax are two large black spots, and on the wing-covers are six large black spots, of which two are on the edges of the wing-cover, so when the wings are closed there appear to be ten spots. This deep-red color and the very large spots make the insect an easily-recognized one. This is also a very

common species, but it is more usually found on wild plants, feeding upon the lice which infest them, although it very frequently appears in our fields, and always as a friend. The rapidity and thoroughness with which these species of lady-birds sometimes work was extremely well illustrated in a large melon-field which I examined three years

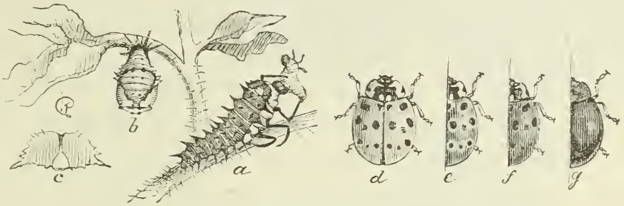


Fig. 126.

Fifteen-spotted lady-bird and varieties: *a*, larva; *b*, pupa; *d*, beetle. (After Riley.)

ago at Esopus, N. Y. This field of thirty acres, all in cantaloupes, had become infested by the melon louse at one corner, and the insects had swept along, taking nearly half of it before the lady-birds got a fair start. In September, when I visited the field, I found that where the lice had first started they had been entirely destroyed by lady-birds, nearly all of them belonging to the species which I have described, and that they were rapidly getting the advantage of the lice in every direction. A great part of the field had been entirely freed from them, and larvæ and beetles were among their prey everywhere, and were busily engaged in feeding. Unfortunately, however, the damage had already been done, and, busy as the insects were in devouring their prey, they could not restore the melons that had been destroyed. Thus, no matter how effective such insects may be, they can never replace to the farmer what is once lost, nor can they be used as a substitute, in any sense of the word, for an active, intelligent campaign by the farmer himself.

Fig. 127.

Megilla maculata. (After Riley.)

We have others of the lady-birds that feed on plant lice, but generally upon species that are not troublesome to the farmer. One series is quite a general feeder upon scale insects. These are very much smaller species, as a rule very convex insects, and they are black, often spotted with yellow or red. In this series the larvæ become spined or provided with tubercles of various forms, and they

are somewhat more slug-like in appearance. They belong largely to the genera *Hyperaspis* and *Brachyacantha*. Still another series, also useful in feeding largely upon scale insects, are very small black species belonging to the genus *Scymnus*. Many of them are clothed with fine hair, differing thus at once from all those previously described. These are difficult to distinguish, and as they have comparatively little interest to the farmer, we need not pause to describe them particularly. The general life history of all these species is the same, and, so far as I am aware, all of them pass the winter in the beetle stage, hidden away in crevices, under bark, among rubbish—indeed, wherever shelter of any kind exists—and it is during this season, as I have already stated, that the great loss in numbers takes place that puts these insects at a disadvantage in their start in spring.

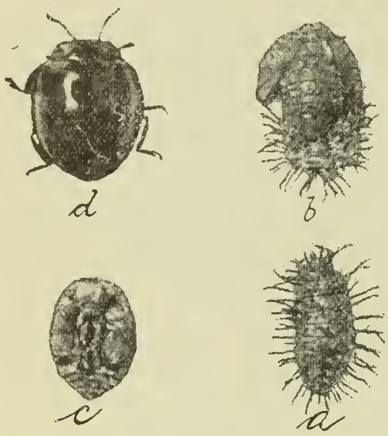


Fig. 128.

Boreal lady-bird, *Epilachne borealis:* a, larva; b, c, pupa; d, adult. (Original.)

As there is no rule without exception, so, unfortunately, there is one instance in our State of a lady-bird that is injurious instead of beneficial. This is the boreal lady-bird, *Epilachne borealis,* which is also called the "squash lady-bird," from its habits of feeding upon the squash plant, both in the larval and adult states. This insect has been described at some length in previous reports, and in Bulletin No. 92 of the Station. It is quite remarkable that we should have, in a family so generally beneficial, this peculiar exception; there being in our country, in the entire series, only three species out of one hundred and forty that feed exclusively upon vegetation, all others being distinctly beneficial. Lady-birds, then, with a single exception only in our State, should be encouraged at all times, and should never be destroyed or interfered with in any way.

It may be advisable, also, to record the fact that aberrations of taste are sometimes found, even in those species of lady-birds that

ordinarily feed upon plant lice. There sometimes come periods when aphids are not to be found in the necessary numbers—early in the season or sometimes late in the year—or where the season has been unfavorable for their development. In such cases the lady-birds will sometimes feed on pollen, or upon the spores of fungi, or upon some forms of fungi themselves, and one of the species, *Megilla maculata*, has even been observed feed-feeding upon the soft kernels of grain. These are exceptional instances, however, and only show that lady-birds do occasionally have bad habits like almost everybody else inhabiting this wicked world.

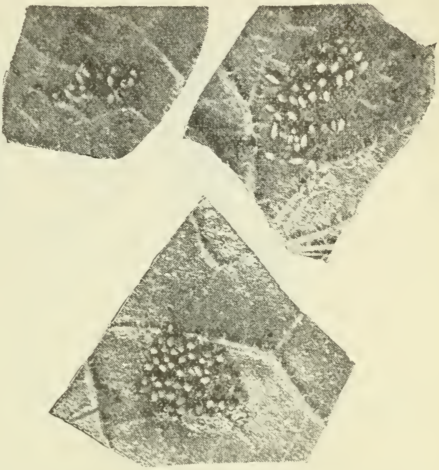


Fig. 129.
Egg masses of the boreal lady-bird. (Original.)

While there are no other families in this series of clavicornes that are as actively beneficial as those which I have already mentioned, there are others that are indirectly advantageous, and occasionally there are some that are positively helpful. Among these which are indirectly beneficial are the *Silphidæ*, or "carrion" or "burying-beetles." These insects feed both in the larval and adult stages upon dead animal matter, and they prefer in many cases small animals, in which they will lay their eggs and which they then undermine, throwing out the soil from beneath until the dead animal sinks a little distance beneath the surface, when it is covered up, and the larvæ of the beetles de-

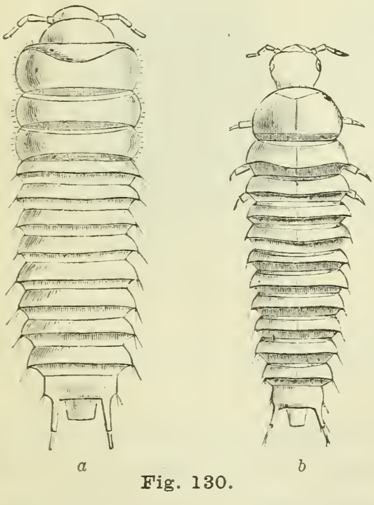


Fig. 130.
Silpha lapponica, larva: *a*, young; *b*, fully grown. Enlarged. (After Packard.)

velop in this decaying matter. The larvæ are usually oval, flattened, quite often black in color, the segments well marked and resembling in some respects the so-called "sow-bugs." The insects

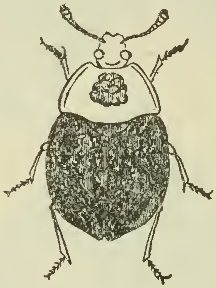


Fig. 131.

Silpha americana. (After Standard Nat. Hist.)

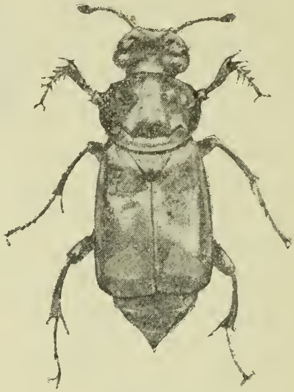


Fig. 132.

Necrophorus americana. (From a photograph.)

are indirectly beneficial in so far as they remove carrion or assist in rendering it innoxious. The adults or beetles differ somewhat in form and are generally contrastingly black and red or yellow in color,

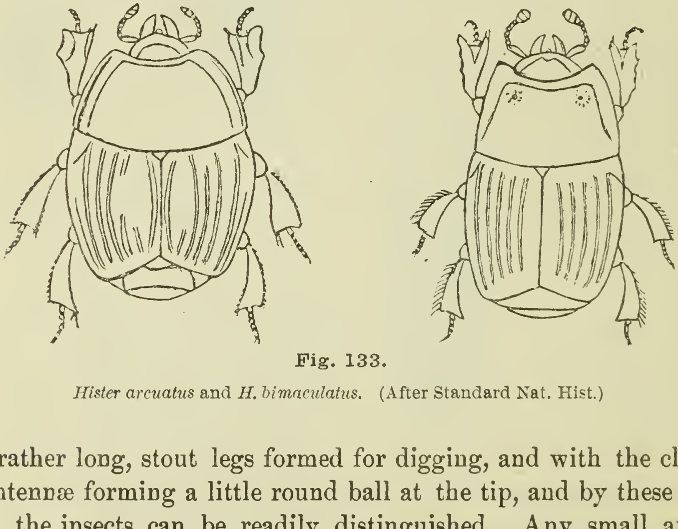


Fig. 133.

Hister arcuatus and *H. bimaculatus.* (After Standard Nat. Hist.)

with rather long, stout legs formed for digging, and with the club of the antennæ forming a little round ball at the tip, and by these characters the insects can be readily distinguished. Any small animal

thrown outdoors and left there over night will be almost certain to attract anywhere from one to a dozen specimens of these beetles, where they can be easily observed.

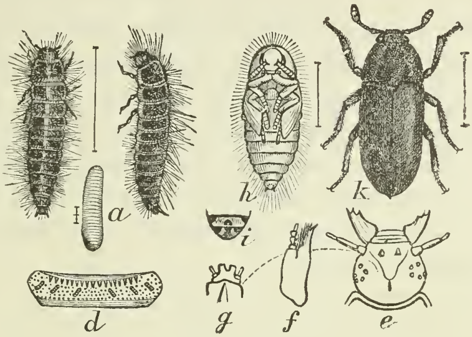


Fig. 134.

Leather-beetle, *Dermestes vulpinus:* *a*, egg; *b*, *c*, larva; *d*, *e*, *f*, *g*, details of larval structure; *h*, pupa; *k*, beetle. (From Rep. U. S. Dept. Agri.)

Another little family somewhat allied to the preceding in habits are the *Histeridæ*. These are more generally found in excrement, in decaying fungi or vegetable matter generally, though frequently also in decaying animal matter. They are small, rounded, sometimes almost

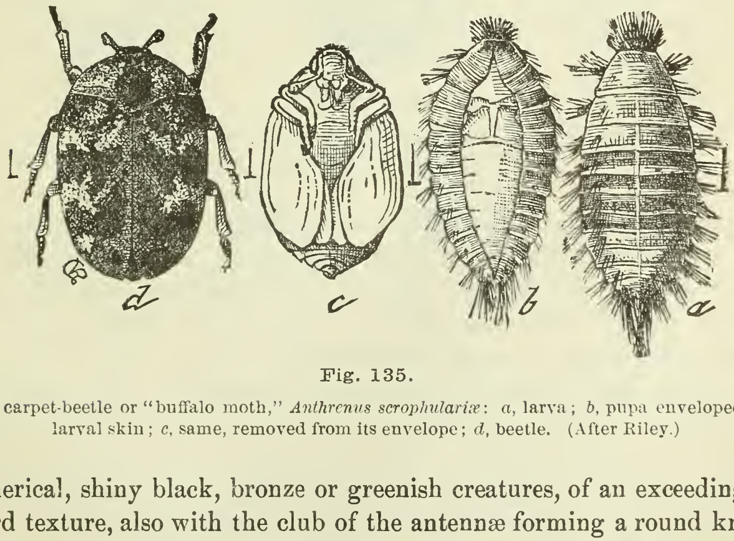


Fig. 135.

The carpet-beetle or "buffalo moth," *Anthrenus scrophulariæ*: *a*, larva; *b*, pupa enveloped in larval skin; *c*, same, removed from its envelope; *d*, beetle. (After Riley.)

spherical, shiny black, bronze or greenish creatures, of an exceedingly hard texture, also with the club of the antennæ forming a round knob at the tip. Their mission in life is much the same as that of the pre-

vious family, though we have some forms that are predaceous in character; that is, they live upon other insects, more usually as larvæ.

Some of the families feed upon dried rather than decaying animal matter, and such are the *Dermestidæ*, which are usually small beetles, oval or sometimes rather elongate in form, with the head very much retracted, and a triangular thorax, the wing covers quite frequently clothed with scales. They are really injurious rather than beneficial, and good examples are the "bacon-beetles," the "carpet-beetle" or "buffalo moth," and the museum pests commonly known as anthrenus. The larvæ are stout, rather active grubs, densely clothed with long, bushy hair. Good representations of some common forms are given in Figures 134 and 135.

Other families prefer to feed in decaying fruits, or on the sweet sap of trees, or in fungi, and among these we need only mention the *Nitidulidæ*, which are usually more or less flattened insects, quite elongate, with the wing covers somewhat shortened and not covering

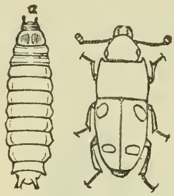


Fig. 136.

Ips fasciatus and larva. (After Packard.)

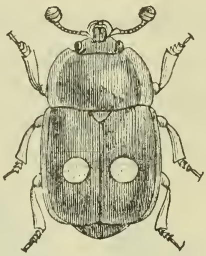


Fig. 137.

Nitidula bipustulata. (After Standard Nat. Hist.)

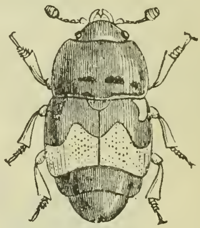


Fig. 138.

Carpophilus hemipterus. (Aft. Standard Nat. Hist.)

the entire abdomen. The head is more distinct, and the antennæ are also usually furnished with quite a prominent club. These insects rarely become troublesome, since only in exceptional cases do they attack sound fruit; although they make their appearance very rapidly where any of it has been bruised.

None of the other families belonging to this series need be specially mentioned, although there are many of them; some living in water, but most of them on land. They are, except, of course, the aquatic forms, essentially species that feed on exuding sap, upon fruit juices, on dead, dry or decaying animal and vegetable matter, and upon fungi, and very few of them are injurious to the farmer. Therefore

beetles that have the antennæ terminated by a more or less obvious club, the other joints not being serrated, can, as a rule, be regarded as at least innoxious and sometimes beneficial. The injurious exceptions need not be pointed out here at present.

Another large series of the *Coleoptera* is that in which the tarsi are five-jointed on all legs, and the antennæ are slender and filiform or thread-like, with eleven joints in most cases; and all of these may be considered as beneficial. They are, as a rule, predaceous, both in the larval and adult stages, and though there are a few cases where the beetles will gnaw the seeds of grasses, yet there are no instances in the entire series, comprising of American species more than a thousand in number, where they are seriously injurious to field or farm crops.

The first of the families in this series is the *Cicindelidæ*, or "tiger-beetles." These are so named from their very active and predaceous habits, and perhaps somewhat also from their colors, which are occasionally bright-banded. The beetles live mostly in sandy spots or along roads, more rarely in meadows or in woods. They have long legs and run rapidly, and fly as readily as they run. They are cylindrical or nearly so, often somewhat flattened and more moderately elongate. The head is large, the eyes quite prominent, and the jaws or mandibles are long, very hard or chitinous, sickle-shaped, and with a fine, sharp-pointed tip. They prey on other insects of almost every

Fig. 139.
Cicindela 6-guttata.
(After Riley.)

Fig. 140.
Cicindela repanda.
(After Packard.)

Fig. 141.
Cicindela generosa.
(After Packard.)

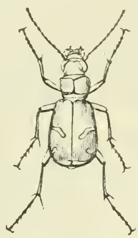


Fig. 142.
Cicindela purpurea.
(After Packard.)

description, and are very voracious. Unfortunately, they rarely go into cultivated fields, and are therefore of less importance to the farmer than some others with similar habits. The larvæ are curious creatures, making burrows, usually in sandy soil, in which they rest

with their head on a level with the surface, waiting for those unlucky creatures that may happen to come in their way. The figures herewith given illustrate both the larva and the beetles, so as to enable them to be recognized rather readily. We have quite a number of species in our State, the most common of which is perhaps *C. repanda*, which is gray in color, with the wing covers banded with yellowish white. This is found in sandy spots and roads, usually in company with a larger, more brightly-banded form, the *C. generosa*. Toward the seashore we have a similar form, but with the thorax clothed with long, fine, white hairs, and hence termed *hirticollis*, while on the shore itself *C. dorsalis* is white, with bronze markings. In the woods or in shaded lanes we find a bright-green form, with six white dots on the wing cover, *C. sexguttata*, while *C. purpurea* is obscure red-brown, with only an inconspicuous band on the wing covers, and it inhabits grassy lands.

Fig. 143.
Larva of cicindelid from side.

The second family belonging to this series is the *Carabidæ*, or ground-beetles. These contain a very large number of forms, usually living on the surface, hiding in the ground, under leaves, sticks or stones, or wherever else they can find shelter. They have the advantage of being able in many cases to live in cultivated fields, both as beetles and in the larva state. Among these are many insects that are extremely important to the farmer, living as they do upon soft-bodied larvæ that they find upon low plants, and that go into the ground. An enormous number of larvæ, like those of the plum curculio or the pear midge, are annually destroyed by insects of this family, and they are of very high importance to the farmer for this reason.

Coming very early in the series we have a number of large forms in which the head is quite prominent and free, the jaws well developed, sharp-pointed, the thorax more or less rounded at the sides, and the body much broader, flattened above. Some of these are from an inch to an inch and a half in length, and many of them are quite prettily colored, often metallic blue or green or bronze, sometimes black. The wing covers are rough and are often ridged and sculptured in various ways. Of these are the so-called "caterpillar hunters" classified in the genus *Calosoma*. These beetles are so called because of their habit of climbing trees and other plants and searching for

caterpillars of various species that feed upon the leaves. It was my fortune to see in Cape May county some three years ago an invasion of spanworms, which were in immense numbers, principally upon

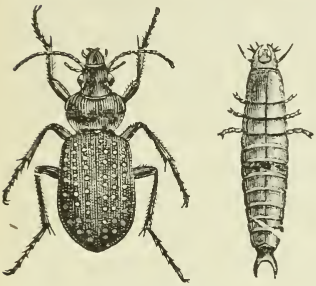


Fig. 144.

Calosoma calidum: the fiery ground-beetle and larva. (After Riley.)

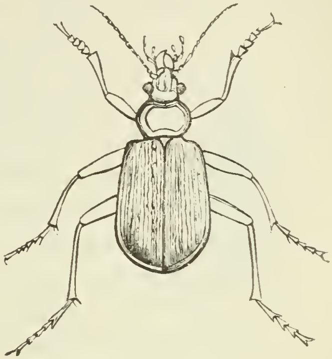


Fig. 145.

Calosoma scrutator. (After Riley.)

the scrub oaks found everywhere throughout that region. On almost every tree could be seen anywhere from one to three or more specimens of the largest of our species, *Calosoma scrutator*, which was preying upon the caterpillars, killing numbers of them, apparently for the mere pleasure of killing, only a small portion of each caterpillar being eaten. A picture of this species and of an allied one, called the "fiery ground-beetle," is given herewith in order to show the appearance of the insects belonging to this series. Species belonging to the genus *Carabus* resemble the preceding in general appearance, but the thorax is usually broader as compared with the wing covers, and the insects are somewhat more regularly oval. Most of them do not have the tree-climbing habit, and live under stones, boards, or in fact any shelter that they can find on the surface of the ground, or around the base of trees. They generally make their forays at night, and are rarely seen during the day, destroying, however, in the course of their lifetime a very large number of caterpillars, and particularly of cutworms, of which they seem to be especially fond. The larvæ of these insects are as rapacious as are the adults, and they do perhaps quite as much good. They live on or in the ground, sheltered under stones, or sticks, or other rubbish, or sometimes under mere clods of earth, and they also make their way out at night,

feeding upon such soft-bodied insects as they can find. They are long, rather slender creatures, flattened above, with prominent jaws, and short antennæ or feelers, and often have horny points or forceps at the end of the last segment of the abdomen. This character of life is found, essentially, through the entire family, and, so far as I am aware, all of the larvæ are carnivorous, though a few exceptionally attack vegetable matter when their ordinary food is not abundant. Many of the larvæ have the advantage of being able to live in tilled fields, finding sufficient hiding-places in the loose soil or in crevices about the base of plants. They are peculiarly valuable to the farmer from their habit of attacking those insects that live in the soil or below it, or that go into soil to pass the pupa stage. The number of cutworms destroyed by larvæ belonging to this family is enormous, and in potato-fields a very large number of larvæ of the Colorado potato-beetle are captured and destroyed when they go into the ground to pupate. Unfortunately the better cultivated a field the less chance there is for the existence of these larvæ, and of the beetles themselves, in fact. Most of them require hiding-places of some kind, and unless these are convenient the insects of course leave the locality and fix themselves elsewhere. In this way the farmer is sometimes his own greatest enemy, because his method of managing his land is the one best calculated to increase the number of injurious and decrease the number of beneficial insects that find it possible to live in his fields. It is not only the large types which have been described that contain the most useful forms. We have a great many others, much smaller in size, belonging to other genera, notably *Bembidium*, of which a very great number find it possible to live in cultivated ground. These are small, usually quite depressed or flattened forms, rarely more than one-fourth of an inch in length, and very active, running rapidly over the surface of the ground, but rarely attempting to fly. These destroy an enormous number of small insects or the young of larger forms, and are of very great use to the farmer. They are frequently metallic in color, though more usually black or bluish, and sometimes marked with yellow or red on the wing covers. Larger species, some of which are also able to live in cultivated ground, are the species of *Pterostichus*, which average from one-half

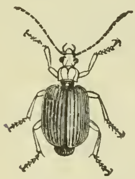


Fig. 146.
Lebia grandis.

to three-fourths of an inch in length. In these the thorax is considerably broader, though usually narrower than the wing covers, and the species are almost, without exception, black, sometimes with a greenish or bronze-metallic luster. Others belonging to this family are more flattened than in *Pterostichus*. The thorax is quite small in proportion to the rest of the body, and the legs are considerably longer, and many of them belong to the genus *Platynus*, which, also, are able to live in cultivated fields. Near allies of this last genus are a series of others which are, if possible, even more flattened, and have the thorax very small compared with the very broad wing covers, which are usually squarely cut off behind and leave exposed a part of the abdomen. These belong to the genus *Lebia* and its allies, and are much more frequently found on plants than any of those heretofore mentioned; one of them, *L. grandis*, has been noticed on potato plants eating the eggs and young larvæ of the potato-beetle.

Fig. 147.

Harpalus caliginosus. (After Riley.)

Following these, we have a series of species in which the thorax is broader—as broad, or nearly so, as the elytra, or wing covers. They are more heavily built and less active than those heretofore mentioned. The head is smaller but massive, and the jaws are broader

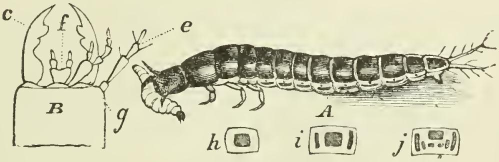


Fig. 148.

Larva of *Harpalus* feeding on a curculio larva. (After Riley.)

and apparently stronger. Among these, we find species which still are, in general habit, carnivorous, and yet have been observed, in some instances, feeding upon vegetation, particularly upon seeds of grasses, and even upon corn. None of them, so far as I am aware, have been considered as really injurious, and the benefits to be derived from them are far in excess of what little injury they may cause by feeding upon seeds or occasionally on pollen. Figures illustrating

all the types that have been mentioned will be found scattered through the text, and will aid the farmer in recognizing the appearance of the beetles of this family that may be considered friendly to him. I may repeat, that all insects in which the tarsi, or feet, are five-jointed, and the antennæ are filiform and thread-like, usually eleven-jointed, may be considered as beneficial, or at least harmless insects, and they should, under no circumstances, be disturbed. There are several other families belonging to this same series with five-jointed tarsi, and they are all more or less predaceous species; but all of them live in the water, and therefore have little or no interest for the farmer.

We have another large series of species comprising a considerable number of families, all of which are distinguished by having the tarsi of the first and second pair of legs five-jointed, while the tarsi of the posterior pair are four-jointed, whence they are called *Heteromera.* There is quite a little tendency among the forms belonging to this series to have the joints of the antennæ more or less bead-like, or as it is termed by entomologists, moniliform, especially towards the tip, where it is not infrequently somewhat enlarged. A large proportion of all the species belonging to this series live on dead vegetable matter, frequently under bark of trees, often in decaying wood, sometimes in fungi either fresh or dried, occasionally in stored products, and rather rarely upon living vegetation.

The most interesting family belonging to this series is the *Meloidæ*, or as they are commonly termed, the blister-beetles. These insects have been used in Oriental medicine as early as history gives any account of the mode of treating diseases, but however curious medical properties they have, they are to the naturalist still more curious on account of their remarkable life history and the strange modifications which parasitism has produced in the larval forms of many of them. The beetles themselves are generally of medium or large size; the vertical head is abruptly narrowed behind into a neck, the thorax is more or less cylindrical, usually narrower than the head, and almost always narrower than the wing covers, which are usually of a rather soft texture, and are not highly chitinized. The insects that furnish the cantharidin which is used for blistering in medicine are found in Europe, principally in the Mediterranean country, but most if not all of our own species possess this property in a more or less marked degree. Some of the species, therefore, have a distinct economic value

in themselves, but, as has been already indicated, the species are at least in part parasitic, and therefore are of interest also to the farmer. But they are injurious as well as useful, and at least two, if not three, of the species occurring in our State are sometimes destructive in potato fields, where they are known as the "striped potato-bugs" or the "black potato-beetles," or sometimes as the "old-fashoned potato-bugs," the story being that in times past insects of this character were much more common than they are at present, when the Colorado beetle monopolizes most of the attention of the farmer in the potato-field. Yet even the beetles that eat the potato leaves are occasionally useful, because they have been noticed in some instances feeding upon the larvæ of the Colorado beetle. If this habit of feeding on potatoes was the only one to be considered, we need not hesitate long about deciding whether the insects were or were not injurious;

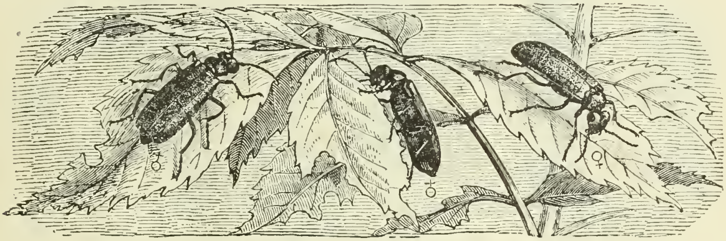


Fig. 149.
The "Spanish fly," *Lytta vesicatoria*.

but unfortunately, if we take the larval history of the insects into consideration, the matter is by no means so clear. In the larval state the blister-beetles are either parasites upon bees or they live in and feed upon the egg-pods of various species of grasshoppers. The development from the egg to the imago in this family is much more complicated than in any other family of beetles, and has been termed a hypermetamorphosis. In brief, it is as follows: The egg is laid on the ground, or sometimes on plants which are frequented by the adults, and from it hatches a larva called a triungulin, which is a very active creature with six legs and a rather slender body. These triungulins or first larvæ run rapidly about, some of them ascending plants, while others live on the ground, their mode of life varying according to what their subsequent history will be. Those forms that ascend plants are usually parasitic upon bees of various

descriptions, and the young larvæ remain about flowers until they have an opportunity of fastening themselves to some bee that is busy in obtaining honey or pollen. Attached to its body, they allow themselves to be carried to the nests, where their further transformations are undergone. If they get into the proper location, that is, among the cells of the bees, the little larvæ make their way into a cell and first devour the egg or young larva of the bee that was intended to occupy it. Thereafter they feed upon the pollen and honey that has been stored up for the larva which they have devoured, and there

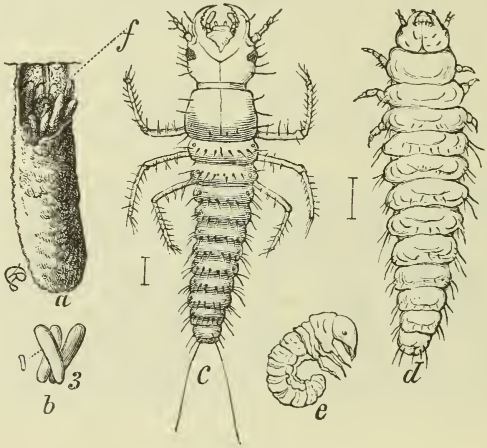


Fig. 150.

Epicauta vittata: *a*, egg-pod of *Caloptenus differentialis* with the mouth torn open, exposing the newly-hatched larva of *Epicauta* eating into an egg; *b*, egg; *c*, first larva or triungulin (greatly enlarged); *d*, caraboid stage of second larva, dorsal view (greatly enlarged). (After Riley.)

they undergo their transformations. These, while they are of extreme interest, need not concern us at present, because bee-parasites, even though of wild bees only, can scarcely be termed beneficial insects from the farmer's standpoint. Others of these triungulins do not ascend plants, but remain on the ground wandering about, able to sustain themselves without food for quite a long period of time, until they find an egg-pod of some species of grasshopper. When they have found this, they enter it, begin feeding and almost immediately moult and cast their skins. The creature that then appears is quite unlike the active form that has hatched from the egg and resembles very much more nearly the larva of the *Carabidæ*, whence Dr. Riley, who has written the life histories of several of our species,

has termed it the carabidoid stage. Another moult or changing of the skin transforms it into a still more clumsy, fleshy larva, which is very sluggish indeed, and resembles in some respects the white grubs, whence it has been called the scarabidoid stage. All this time the insect is feeding upon the eggs in the grasshopper pod, and undergoes yet another moult, which produces the ultimate stage of this second larva. It is now full fed, and for the first time leaves the egg mass in which it has heretofore lived, forms a cavity in the ground, partially moults, and enters what is called the pseudo-pupal stage, in which it is inactive and remains enveloped in the skin which has not been entirely shed. In this stage it usually hibernates or passes the winter, and in spring it rids itself of this old skin, and appears in yet another form, which is called the third larval form. This third larva

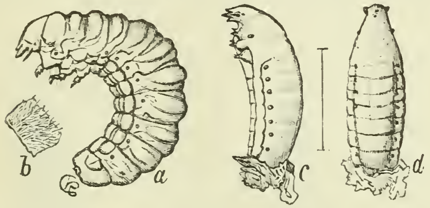


Fig. 151.

Epicauta vittata: *a*, full-grown stage of second larva; *b*, portion of the dorsal skin of same; *c*, pseudo-pupa, or coarctate larva, lateral view; *d*, same, dorsal view. (After Riley.)

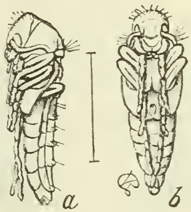


Fig. 152.

Epicauta vittata: *a*, true pupa, side view; *b*, same ventral view. (After Riley.)

burrows about in the ground without feeding, in due time forms a normal pupa and soon thereafter the imago or adult beetle emerges. This egg-feeding habit of the blister-beetle larvæ is an extremely important one, and there is no doubt whatever that some of the grasshoppers in this State are kept down to a very great extent by the insects of this family. In the year 1892 grasshoppers, through climatic causes, became exceedingly abundant, and were very injurious in many parts of the State. As a matter of course, eggs were deposited everywhere, and probably the great majority of all the triungulins of every proper species of *Meloid* succeeded in finding pods in which to undergo their transformations. In this way the supply of grasshoppers for 1893 was undoubtedly much lessened, but at the same time the number of blister-beetles was correspondingly increased, and when they emerged they at once began feeding upon

their favorite plants. We have here a rather nice question which has been once before stated: Are these insects more beneficial than injurious, or more injurious than beneficial?—is the damage that they cause by feeding upon potato vines greater than the benefit derived from the destruction of grasshopper eggs or is the contrary true? This question will not be decided in the same way by farmers generally, and a local reason will usually turn the scale in one direction or the other. Personally, I think that the insects are very much more beneficial than they are injurious, for their injury can be checked in most cases without any very great difficulty, if poisons are applied in time, and at the worst the insects remain only for a very short period and rarely do damage which is not readily made good by the plant after they leave. We must consider each blister-beetle to be the representative of all the grasshoppers that would otherwise have issued

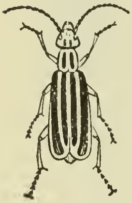


Fig. 153.

Epicauta vittata, imago. (After Riley.)

Fig. 154.

Epicauta cinerea. (After Riley.)

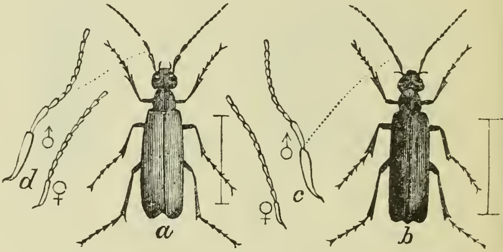


Fig. 155.

a, Macrobasis unicolor; b, Epicauta pennsylvanica. (After Riley.)

from the egg-pod in which it passes its early stage, and it is scarcely questionable which would have done the most damage, a single beetle feeding for a week at the outside, or fifty grasshoppers feeding for six weeks or more. The sudden re-appearance of these blister-beetles in great numbers in 1893 is thus readily accounted for, and we need have no apprehension that next season will see an increase. We will more probably see a decided decrease, since grasshoppers were much less abundant in 1893 than in 1892. In our State there are three species that have been either proved to be parasitic upon the eggs of grasshoppers, or which are, probably with justice, suspected of being so parasitic, and these will be briefly mentioned here.

Perhaps the most common of these is the "striped potato-beetle," *Epicauta vittata.* This is a dull-yellowish insect with black stripes,

and it makes its appearance about midsummer, or a little earlier. Somewhat less abundant is the "black potato-beetle," *Epicauta cinerea*. This is a somewhat larger, more robust species, black in color, the thorax marked with a central, pale ashen-gray streak, and the wing covers edged at the sides and where they join with a narrower streak of the same ash-gray color. It frequently occurs with the preceding, and the two may make their appearance in the potato-field at the same time. From the peculiar life habits of the species, it will be seen that they become full grown and enter the pupa state at about the same time, and that the same weather conditions which favor the maturing of one specimen favor also the maturing of all. Therefore instead of the insects making their appearance gradually, the entire brood seems to issue at once. Appearing thus in enormous swarms at one time, they frequently do considerable damage before the farmer realizes that there is any trouble brewing. The third species to which reference was made is the *Epicauta pennsylvanica*. This is smaller than either of the others, seldom infests potatoes, and is easily recognized by being entirely black in color. It usually makes its appearance somewhat later in the season, and is often found in very great numbers on the golden-rods. Appearing suddenly as they do, the insects disappear nearly as suddenly and completely. They may be about a field a week or ten days, and then disappear and leave no trace. Some other, rare species, occur occasionally in our State, and these may be sometimes observed in considerable numbers on one day only, disappearing absolutely a day or two afterward, not to re-appear until the following season. As a whole, I think we may consider that the blister-beetles are more beneficial than otherwise; but where they appear in troublesome numbers in potato-fields, I would not advise the farmers to hesitate about destroying them. The best method for doing that is to gather them in pans early in the morning before they fly readily. The pans should have a little water with a scum of kerosene floating on it, and this will kill or disable the insects as soon as they are immersed in it. Another method which is often successful, is to drive the insects. During midday they are easily disturbed and fly readily, and they can be driven from a field with comparative ease. Frequently a layer of straw is spread on one side of the field and into this the beetles are slowly driven, the straw being then set on fire and the beetles burned.

None of the other families belonging to this series of *Heteromera*, so far as they occur in our State, can be considered as beneficial. We have a number of families represented, but comparatively only a few species occur with us. It is in the high Western plains, on the Rocky mountains and in their valleys, and along the Pacific coast, that we find these families at their best, and there are many points where the species belonging to this type constitute the great majority of the fauna, not only in number of species, but in number of specimens as well. A type of the family *Tenebrionidæ*, which is the largest, or that containing the greatest number of species in this series, we can find in the common "meal-worm," which is familiar to most farmers. The larva is quite usual in grain bins or neglected meal bags in stables, and in fact wherever flour, meal, bran or even grain is carelessly left for a long time. The larva is an inch or more in length, rather slender, cylindrical, somewhat flattened, with a yellow head, six small legs, and a hard terminal segment, ending in two small brown points. When it is full grown the larva changes to a pupa in the places where it has been feeding, and out of it comes a black beetle nearly three-fourths of an inch in length, which is oblong, the sides almost parallel, and is considerably flattened. Many of the members of this family can be found under the bark of trees, and some of them in decaying wood, where the larvæ probably find their subsistence. Other forms are more partial to tree fungi, and the same habits are found represented in the majority of other families belonging to this series. So far as I am able to remember, very few of the species belonging to this series of *Heteromera*, so far as they occur in our State, can be considered as seriously injurious, and on the other hand, with the exception of the blister-beetles, none of them can be considered as beneficial.

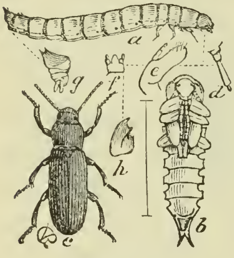


Fig. 156.

Tenebrio obscurus, the meal-worm: *a*, larva; *b*, pupa; *c*, beetle. (After Riley.)

The last order of insects of which mention will be made, and in some respects very much the highest in point of development, is the *Hymenoptera*. This includes bees, wasps, ants, saw-flies, gall-flies, ichneumon-flies and others of similar character. We have an enormous number of species belonging to this order, perhaps more than in

any other, and we have only an extremely imperfect knowledge of those existing in our country. In this entire order there are very few that are really injurious, and on the other hand we have an enormous number that are of the highest value to the farmer. The *Hymenoptera* are mandibulate; that is to say, they are furnished with a pair of stout jaws or mandibles, and are thus able to chew their food. A considerable number of the species, however, are furnished with a long, tongue-like organ, which enables them to gather honey from the nectaries of flowers, and others which, while the tongue is not elongate, have it extremely sensitive, and apparently bladder-like, suitable

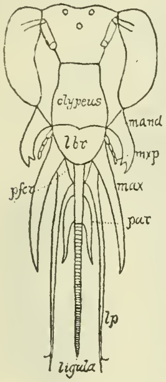


Fig. 157.

Head and mouth parts of bee; the tongue central. (After Newport)

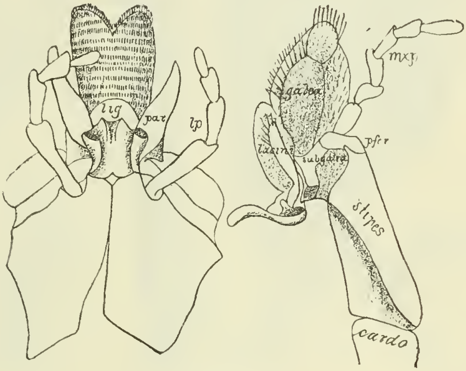


Fig. 158.

Mouth parts of a paper-making wasp, showing at *lig*, the bladder-like tongue. (Original.)

for lapping up liquids. These insects have four wings, except in isolated cases, and these wings are transparent, with a few longitudinal and transverse veins, forming only a small number of cells on the wing. As a rule the hind wings are very much smaller than the first pair. Sometimes, in the small forms, the venation may be entirely obsolete, or there may be only a small spur along on the costa or anterior margin.

There is one series, and only one, in this order, all the members of which are injurious and are plant-feeders. These are the *Phytophaga*, or leaf-eaters, and include the so-called saw-flies, the larvæ of which resemble caterpillars in general appearance, but differ from them obviously by having an extra pair of false legs. Many of them have

also the habit of curling up the posterior part of the body when feeding, and quite a number of them seem to prefer feeding at the edge of the leaf, letting the hind body hang free. We have some troublesome insects among these saw-fly larvæ, and I need only instance among them the currant-worm, which is perhaps the most abundant and

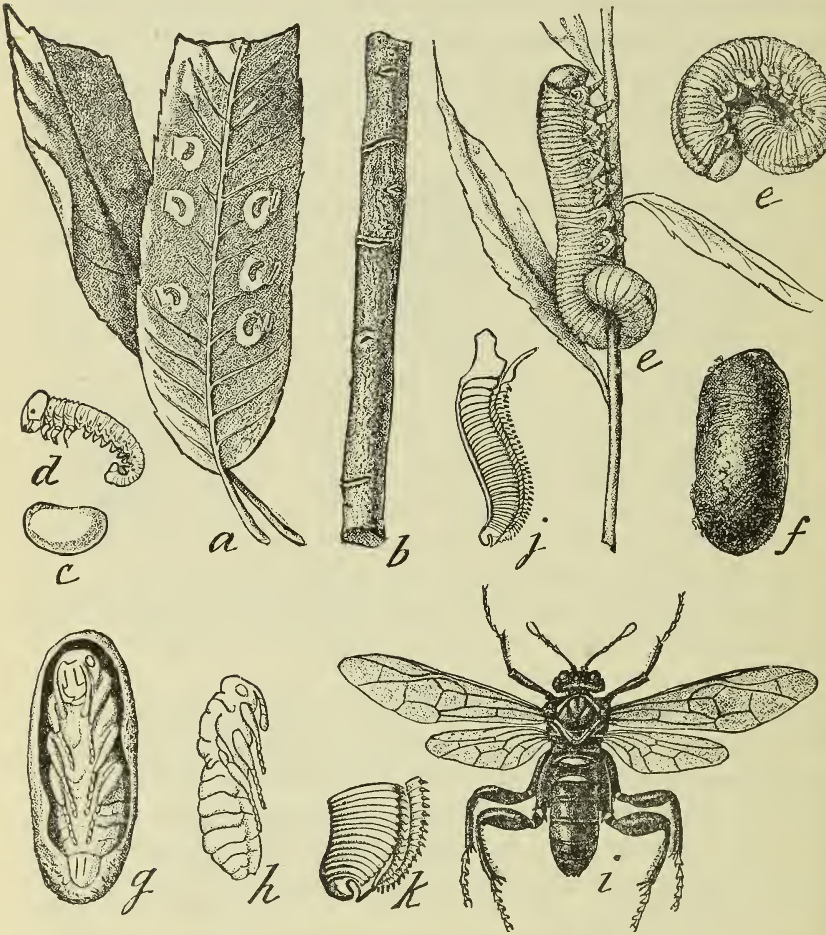


Fig. 159.

The large willow saw-fly, *Cimbex americana:* *a*, willow leaves showing egg-blisters from above and below; *b*, twig showing girdlings; *c*, egg; *d*, newly-hatched larva; *e*, *e*, full-grown larvæ; *f*, cocoon; *g*, cocoon cut open, with pupa; *h*, pupa, side view; *i*, male fly; *j*, saw of female detached, side view; *k*, tip of do.; *c*, *d*, *j*, *k*, enlarged, the rest natural size. (After Riley.)

most generally distributed. The adult saw-flies can usually be distinguished from the other members of the order from the fact that the base of the abdomen is united by its full width with the thorax, whereas in most of the others the connection between the thorax and abdomen is reduced to a small stalk, sometimes so slender that it would seem as if the least touch would suffice to break the insect in halves. Insects like the saw-flies are said to have the abdomen sessile, while insects like wasps, which have an exceedingly narrow waist, are said to have the abdomen petiolate or stalked. The peculiarity from which the common term "saw-flies" is derived is found in the structure of the ovipositor or egg-laying tube in these insects. Instead of being a mere pointed sting, or a long or short tube, the ovipositor is formed of four distinct blades, which are toothed like a saw in the majority of cases, although some of the combined blades have a good deal more of an auger or gimlet shape. By means of these saws, slits or pockets are cut into the leaves or other tissue on which these insects feed, and the egg is laid in the cavity thus made. These saws make beautiful objects under the microscope, and the variety found is almost infinite; sometimes of the simplest possible construction, sometimes complicated in the most diverse ways. It is rather interesting to note that almost all the types of saws that are in use by mechanics, for almost all sorts of work, including ice-cutting, are already represented naturally in these insects. It might pay some mechanical genius to study these insect structures with the idea of seeing whether it would not be possible to learn something new in mechanics from them. The subject of saw-flies is of sufficient importance to require a special treatise, which would of course not be in place here.

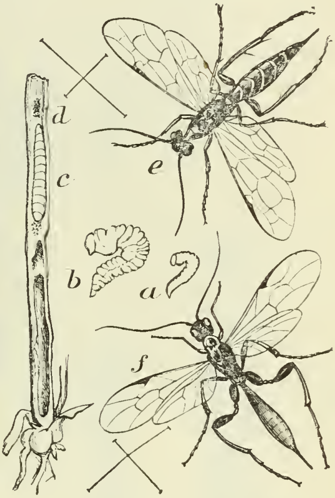


Fig. 160.

Cephus pygmæus, wheat-stem saw-fly: *a*, outline of larva, natural size; *b*, larva enlarged; *c*, larva in wheat stalk, natural size; *e*, adult female; *f*, female parasite, enlarged. (After Curtis)

Nearly allied to the true saw-flies are others resembling them somewhat in general appearance, but usually larger and, in many cases, with a longer ovipositor, which extends beyond the end of the abdomen and is not concealed. These lay their eggs in the trunks of trees, or in herbaceous plants, and the larvæ are internal feeders, boring large holes and often causing great destruction, especially to pine timber. We have one very large species that is rather common, known as the pigeon-tremex, and of this a figure is given, and at the

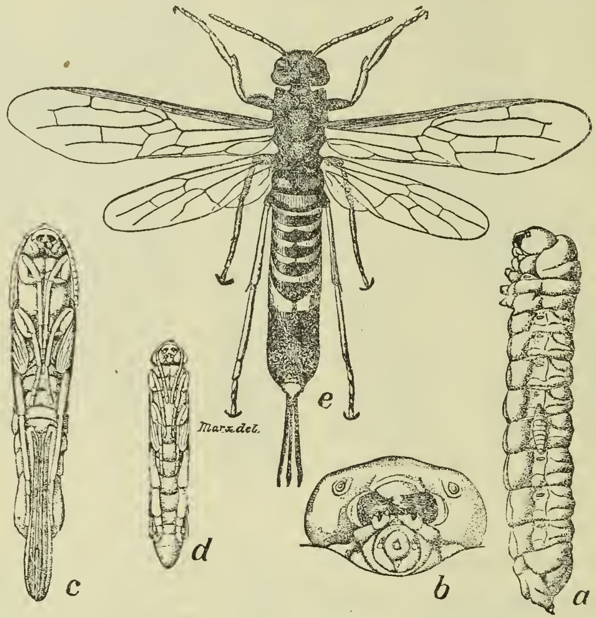


Fig. 161.

Tremex columba: a, larva, showing *Thalessa* larva attached to its side; b, head of larva, front view, enlarged; c, female pupa, ventral view; d, male pupa, ventral view; e, adult female. All slightly enlarged. (From "Insect Life.")

same time its parasite is also shown fastened to the larva; of this, I will again speak later on. Others bore in stems of wheat and grasses, and in the annual report for 1892, I described and figured a species boring in blackberry canes.

Following in the natural series those that have been just mentioned, we reach the immense series *Parasitica.* This comprises some of the largest families of the order, the members of which, in their larval state, excepting the gall-makers, are parasitic upon or

within the bodies of other insects. Using the words of Westwood, "these are of vast importance in the economy of nature by preventing the too great increase of different species of insects, especially of the

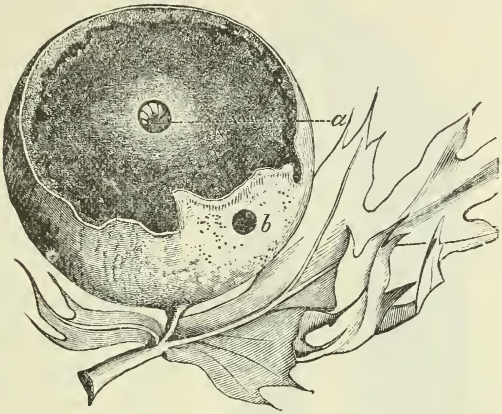


Fig. 162.

Gall made by *Cynips q. spongifica* on oak. (After Riley.)

caterpillars and moths, of which they destroy a great number." A very common character found in the parasitic forms is the presence of an exserted ovipositor; but this is not by any means a universal feature, and in very many cases it is short, concealed and occasionally formed like a sting.

The first of the families of the *Parasitica* is the *Cynipidæ*. The species of this interesting family are all small in size, the head is inconspicuous, the thorax usually robust, the abdomen generally oval and more or less compressed, sometimes even knife-shaped, and the ovipositor is spiral and concealed within two sheaths or plates. We have really two sections in this most interesting family in which the habits are distinctly diverse; but the characters separating the two sections are of such a nature as to be not easily recognizable,

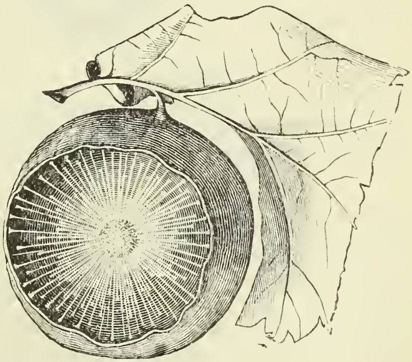


Fig. 163.

Gall made by *Cynips q. inana* on oak. (After Riley.)

except by the special student. One of the sections contains, rather, plant parasites—that is to say, the larvæ do not feed upon the plant tissue as do most other insects; but they cause a swelling or excrescence, or a gall, and in the substance of this abnormal growth the insect lives. These galls are of the most diverse shapes, and the species is almost always recognizable by the gall it makes. Oaks are especially infested, and many species feed upon this tree. Sometimes cultivated plants are attacked, as, for instance, the blackberry; and roses occasionally suffer, but, practically, little real damage is done by them. The galls are not always upon the stems or leaves of the plants; but in some instances the roots are attacked and galls are formed underground. There are many interesting features in the life history of these species, which it would be out of place to call attention to here, and it must be left to the figures and what little I have said of a descriptive nature to give an idea of the appearance of the work of the insects.

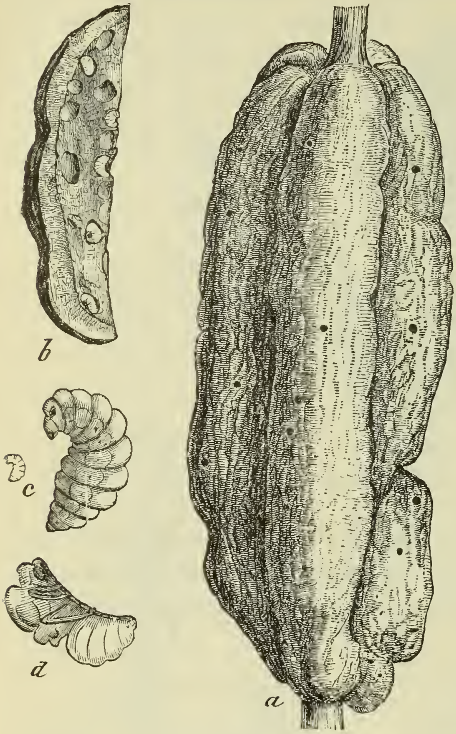


Fig. 164.

Pithy gall on blackberry made by *Diastrophus nebulosus*: *a*, gall from which insects have emerged: *b*, a section through, showing cells; *c*, larva; *d*, pupa. (After Riley.)

Two or three small families come in at this point which cannot be given a special reference here, and then we reach the great family *Ichneumonidæ*. This very extensive family is distinguished from the other parasites by having the wings with tolerably complete venation as a rule, a rather large, prominent head, with long, slender antennæ, which are never elbowed; a moderately large and well-developed thorax, rather long and slender legs, and a long, somewhat ovate or

cylindrical abdomen, which, however, varies quite considerably. The ovipositor varies in length, but is quite often exserted or extended, and is attached before the apex or tip of the abdomen. Among the species of ichneumon we have many of our most common parasites, and those,

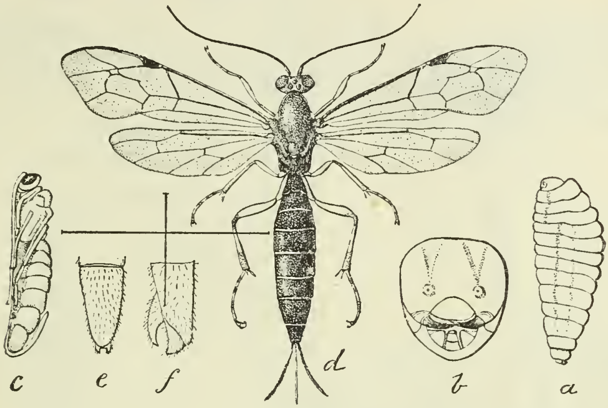


Fig. 165.

Pimpla conquisitor: *a*, larva; *b*, head of do., from front; *c*, pupa; *d*, adult female, hairline indicating natural size; *e*, end of male abdomen, from above; *f*, same from the side. All enlarged. (After Riley.)

too, that infest some of the most injurious of our caterpillars; for, after all, it is caterpillars that furnish a very large proportion of the food for these insects, and of the injurious types these parasites infest

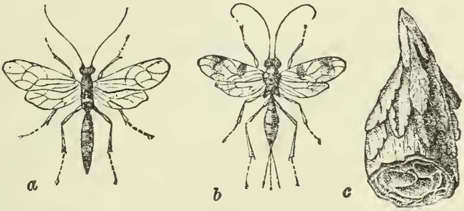


Fig. 166.

Hemiteles thyridopterigis: *a*, male; *b*. female; *c*, sack of bagworm cut open, showing cocoons of parasite. Natural size. (After Riley.)

the *Lepidoptera* most usually. A good illustration of the general form of the insects belonging to this family is shown in Figure 165. Quite a common type belongs to the genus *Trogus*, and is a red or yellowish form, with smoky-black wings. It is parasitic in the cater-

pillar of our common black swallow-tail butterfly, which feeds upon carrots, parsley and the like. The larva of the parasite matures within the body of the caterpillar, which finishes its feeding as though in full health and changes to a chrysalis; but instead of a butterfly hatching from it an ugly hole is eaten into the side and this *Trogus* makes its appearance. Sometimes the species become very large, occasionally with the body transversely flattened almost like a knife blade, and these insects usually have a short, sting-like ovipositor; indeed they are able to use it in their own defense, and I have on more than one occasion proved their ability to penetrate the skin. The puncture, however, does not seem to be particularly venomous, and produces only a brief pain, which disappears without swelling. Some of these belong to the genus *Ophion*, and these are parasitic in the caterpillars of some of our large silk moths. Allied species also infest the yellow-necked apple-caterpillar, and do considerable good in keeping them within reasonable bounds. I have stated that in many cases the ovipositor was quite considerably extended beyond the end of the body, and sometimes this character is enormously exaggerated. This is especially true in the case of the species of *Thalessa*, which contains the largest of our ichneumon-flies, and here it is extended to a length of from three to four inches, and the insects have received the common name of "long-tails." They are frequently seen on tree trunks, and sometimes with the ovipositor inserted for its full length in the solid wood. I have not infrequently received specimens taken in that position, with the statement that they were injuring the trees and boring holes in them. Now as a matter of fact these insects are parasitic upon the larvæ of the *Tremex*, which was mentioned on a previous page, and these long stings or ovipositors are required in order to enable the insect to lay

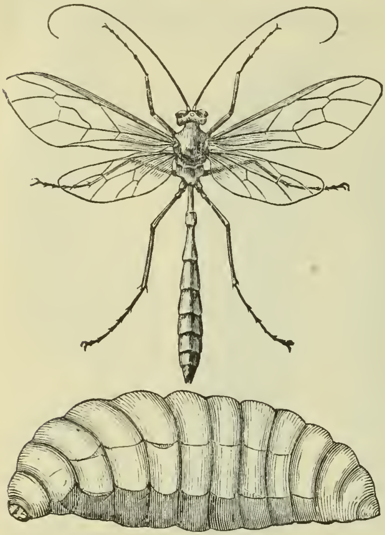


Fig. 167.
Long-tailed ophion, *Ophion macrurum*, and larva. (After Riley.)

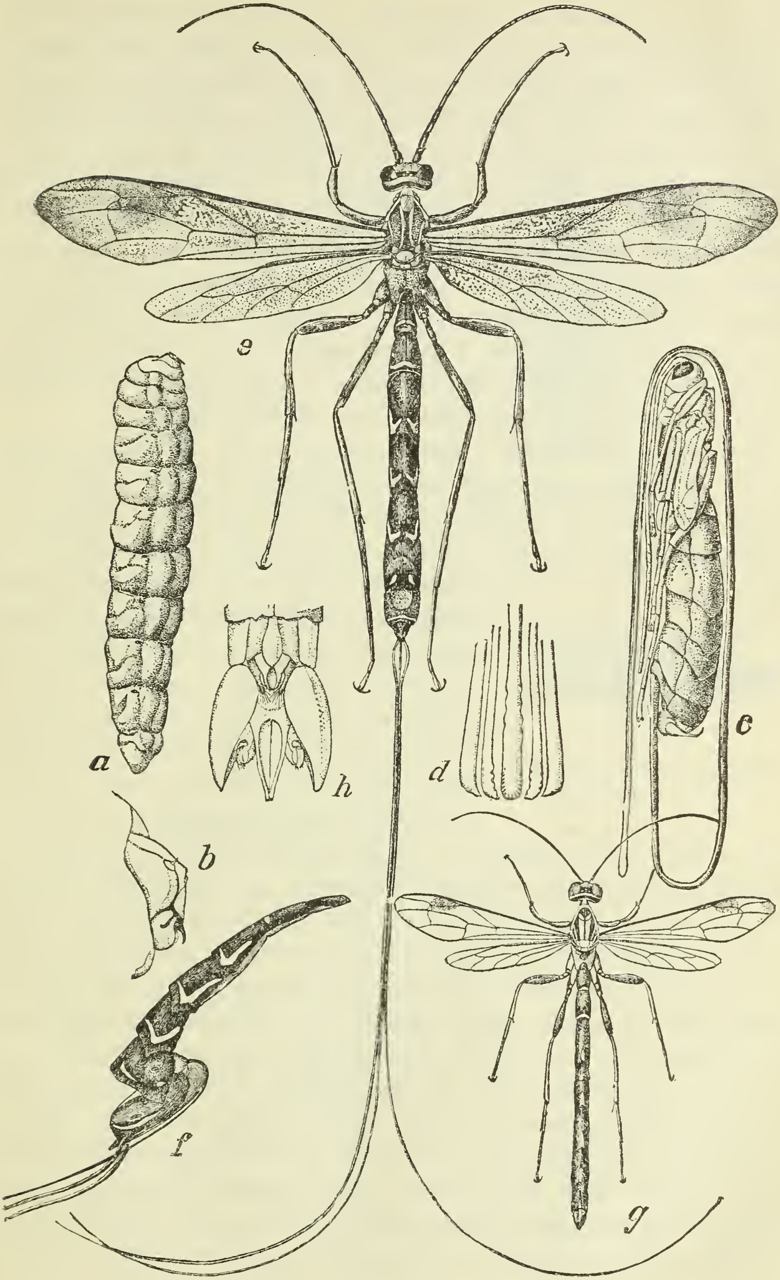


Fig. 168.

Thalessa lunator: *a*, larva; *b*, its head, from side; *c*, pupa; *d*, tips of ovipositor of pupa; *e*, adult female; *f*, abdomen from side; *g*, adult male; *h*, tip of abdomen of same. (From "Insect Life.")

its eggs in the burrows of these borers. It is a most marvelous provision of nature for a very special purpose, and these insects seem to be enabled by some instinct to recognize the trees which are infested by their prey. With infinite labor and toil they force their ovipositor from two to four inches into the solid wood to get the opportunity of striking a burrow and laying an egg in it. The life history of this insect has been worked out by Dr. Riley, and the figures given, which illustrate this insect, were first used by him. We have many other genera and species that are of importance belonging to this same family, but it is naturally impossible to speak of them all here, and I can only endeavor to give a general idea of their appearance, showing their characters sufficiently to enable one to make at least a shrewd guess as to the probable relations of any insect observed.

The family *Braconidæ* is closely related to the preceding family, and is distinguished largely by the difference in the wing veins, which we need not trouble ourselves with trying to understand. There are a great number of species belonging here, and some of the forms are quite large, with more robust bodies than in the previous family. These sometimes have the abdomen contrastingly red, while the thorax and head may be black, and such forms are often members of the typical genus *Bracon*. Here, also, we find quite generally a more or less lengthily-extended ovipositor. We find, also, a very great number of small species; and those sometimes inhabit caterpillars in very great numbers. A well-marked instance is in the case of those which attack the tomato-sphinx larva. This will be sometimes noticed when it is full grown, or nearly so, covered with small, white, oval bodies like seeds or eggs, and indeed they are quite generally looked upon as eggs of the caterpillars and destroyed by farmers. As a matter of fact, however, they are the cocoons of the little parasites that have infested the caterpillar, and if the latter is watched when these larvæ first begin issuing from it, it will be noticed that from all parts of the skin little maggots begin poking their heads through little holes. They generally wriggle out until they are held only by the last segment, and then they begin spinning the little silken cocoons in which they change to a pupa. At this

Fig. 169.

Microgaster cocoons on sphinx larva. (After Riley.)

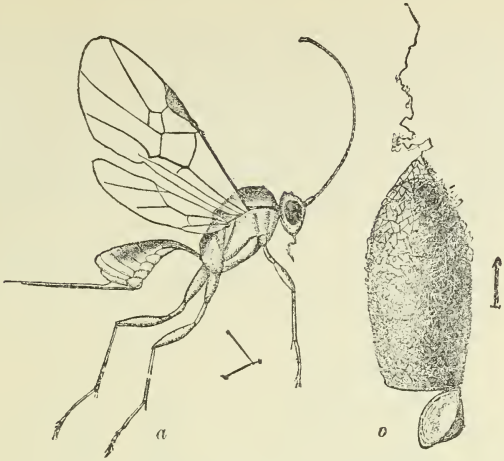


Fig. 170.
Meteorus hyphantriæ, parasite on fall webworm, and its cocoon. (After Riley)

time the caterpillar becomes flabby and dies, while in a very few days a little lid is separated from the top of the cocoons, and out of each comes a little wasp-like creature belonging to this

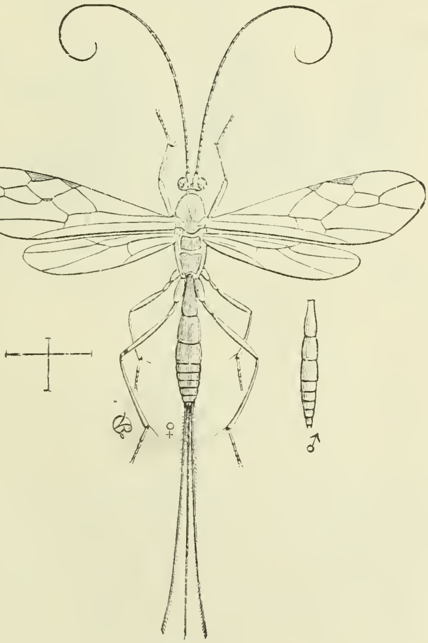


Fig. 171.
Macrocentrus delicatus, parasite on codling moth, cranberry-vine worm, etc. (After Riley.)

family *Braconidæ.* These little egg-like bodies should never be disturbed, and under no circumstances destroyed. Each contains an active friend of the farmer, and were there enough of these, not a caterpillar of some species would succeed in coming to maturity. We have a very large number of species belonging to this type which spin little cocoons; but they do not always work their

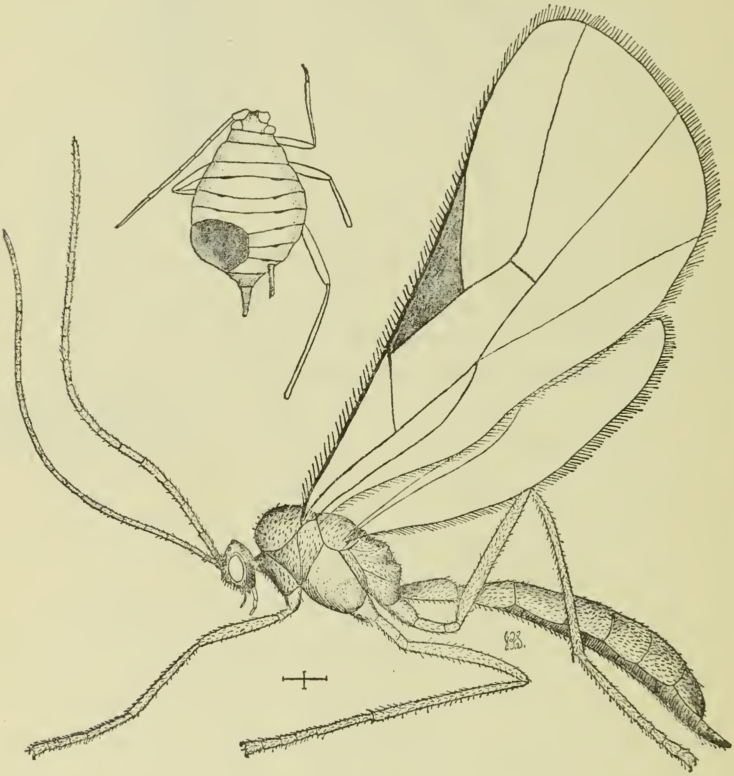


Fig. 172.

Aphidius granariaphis, showing above the parasitized louse from which it has issued. (Original)

way through the skin, as has been described above. Sometimes the caterpillar will make a cocoon, and the parasites do not interfere with it until this is completed. Then, however, they destroy it, and in the cocoon made by the caterpillar there will be found, instead of a pupa, a mass of these little braconid cocoons. Not all of them, by any manner of means, make cocoons, and sometimes they change to a

pupa within the body of a chrysalis permitting the caterpillar to complete its changes to that point. Not only caterpillars, however, are attacked by insects of this family, but insects of other orders as well, and a great many of the smaller species attack plant lice, a single plant louse furnishing food enough for the development of the larva of one of these little parasitic wasps. We have a number of species which are thus extremely useful, as, for instance, those which infest the melon and wheat aphids. I have seen them so abundant in one instance when the melon lice threatened injury that I was able to assure the grower that he need have no further fears, that injury

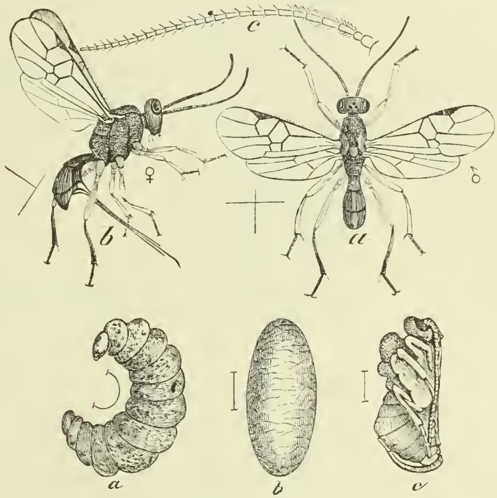


Fig. 173.

Sigalphus curculionis, parasite on plum curculio: larva, cocoon, pupa, and male and female imago. (After Riley.)

was checked for the season, and my prediction proved correct. One of these species was figured and described in Bulletin No. 72 of the Station as infesting the wheat louse, and this is extremely important in our State. Infested plant lice lose their green color, take on a bloated look and become a livid gray. In a very short time the insect within it matures, and through a little round hole, usually near the posterior end of the plant louse, it crawls into daylight, and almost immediately begins its work of laying eggs into other aphids.

Next follows the family *Chalcididæ*. This family is composed of

a large number of insects, generally of exceedingly small size, many of the species having pretty metallic colors. The anterior wings are almost without veins, except along the front edge. The antennæ are exceedingly variable in form in this family, are often curiously developed in the males, and are quite usually elbowed. Their habits are parasitic in most cases. Many of them are parasites upon plant lice. A large number live in the eggs of other insects, the parasite being so minute that it finds a sufficient amount of nourishment in a single butterfly egg! Many of them, again, are parasitic upon other parasites—that is to say, they will lay their eggs, not in an injurious

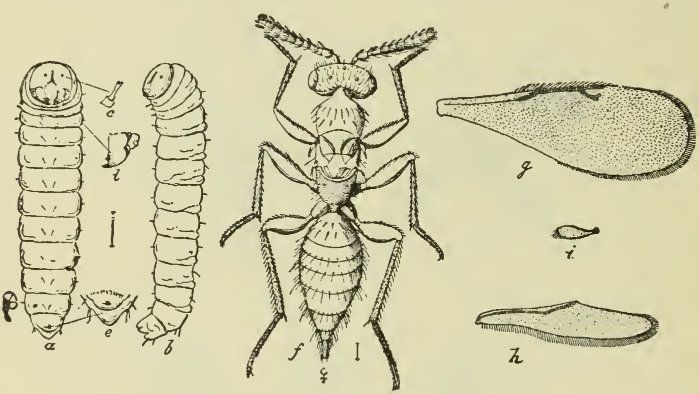


Fig. 174.

Isosoma tritici: *a, b,* larva ; *f,* adult female ; *g,* fore wing ; *h,* hind wing. (After Riley)

species, but in one of the parasites infesting it, and thus their parasitic habit might in some cases render them rather injurious than beneficial. It oddly goes to prove the truth of Dean Swift's famous couplet:

> "The little fleas that do us tease
> Have other fleas that bite 'em,
> And those in turn have other fleas,
> And so on *ad infinitum.*"

We have, belonging to this family, some forms that are aberrant in their habits, departing from the usual type of development, and living in plants and feeding upon them. Such are the species of the genus *Isosoma,* which live in the stems of wheat, rye and other grasses, somewhat in the same manner in which the Hessian fly infests them, and causing occasionally quite marked injury. None of

these forms seem to be troublesome in our own State, or at least I have never had them brought to my attention; but in the Western States, where wheat forms the staple, they sometimes cause appreciable damage. Many of the forms deposit their eggs in various galls, and the larvæ feed upon and destroy the legitimate inhabitants. Sometimes dozens of galls may be collected, and hundreds of specimens may be bred from them, and not a single specimen may be obtained of the species to which the gall is really due. So far as New Jersey is concerned, this family can be considered as equally beneficial with any of the preceding, and particularly from the plant-louse infesting habits of many of the species. A great many members of this family infest also micro-*Lepidoptera*, and the Angoumois grain moth, among others, is often badly infested. A very large number have been described, but it is probable that not one-tenth part of the actual number of species has yet been studied.

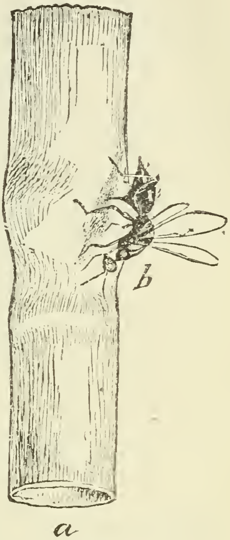


Fig. 175.

Isosoma ovipositing in stem of wheat. (After Riley)

Following the *Chalcididœ,* we have the family *Proctotrypidœ,* many of which resemble the former family; but are always distinguishable by the fact that the ovipositor is attached at the end of the abdomen, while in the others it is always attached at some distance before

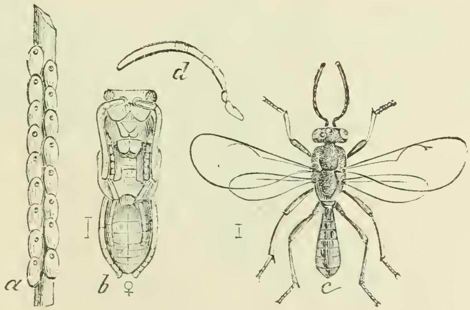


Fig. 176.

Eupelmus mirabilis, katydid-egg parasite: *a,* eggs from which parasite has emerged; *b,* its pupa; *c,* mature insect. (After Riley.)

the end. This is a character that is easily seen by the student; but is of very little importance practically to the farmer, who is more especially interested in knowing the fact that the members of this

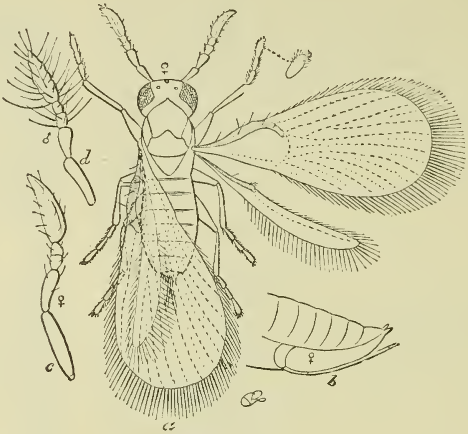


Fig. 177.

An egg parasite, *Trichogramma pretiosa.* (Greatly enlarged.) (After Riley.)

family, which are generally small and are usually shiny, black or brown in color, are equally valuable to him from the economic standpoint, and that all of them are parasitic. We have a very large

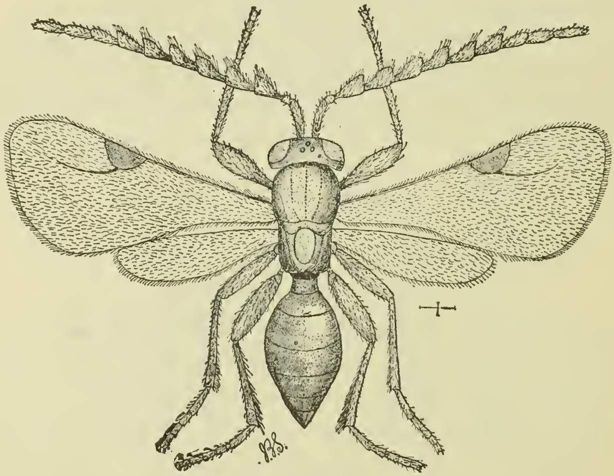


Fig. 178.

Ceraphron triticum, wheat-louse parasite (Enlarged.) (Original.)

number of species which have just been monographed by Mr. W. H. Ashmead, who has shown that they are parasitic upon several orders of insects, and among others upon a large number that are injurious to the farmer. Among these also we have a great many that are parasitic upon plant lice, and in their general form and appearance they resemble the species of the other parasitic families. A figure of *Ceraphron triticum,* which also is parasitic on the wheat louse, is added to show the form of some of the species.

A most remarkable family is the *Pelecinidæ,* and specimens of the only species belonging to the family are not rarely met with. It is black, nearly two inches in length and very slender; remarkable for the very great length of the jointed abdomen, giving the insect a

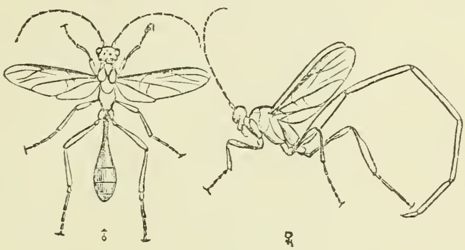


Fig. 179.

Pelecinus polyturator, male and female. (After Packard.)

characteristic appearance that is not to be mistaken. This structure, however, is found in the female only, and the male is rarely seen, having the appearance of a wasp. We have no certain knowledge as to the habits of this insect, large as it is; but it is supposed to be parasitic.

We are now at the end of the truly parasitic families whose mission in nature seems to be to check and keep within due bounds insects of many different kinds, and they themselves are kept in check by others that prey upon them, and by climatic and other factors. We may have some years a very great abundance of parasites, so it will be difficult to find caterpillars that are not infested, and it would seem as if, under ordinary circumstances, in the year following, freedom from insect pests would be assured; yet in some mysterious way during the winter the balance will seem to be changed and the following season may bring forth a great lot of caterpillars and few or no parasites; or a series of years may occur in which parasites are

abundant, followed by another series of years in which they seem to be rare.

We have an odd little family called the *Chrysididæ*, or "cuckoo-bees," which in a sense are parasitic, because they build no nests of their own and store up no food-supply but watch their opportunity to lay their eggs in the nests of other bees and wasps, usually of the solitary forms. These eggs hatch sooner than those of the legitimate inhabitant of the cell, giving the intruder a chance to feed upon the food stored by the maker and come to maturity, leaving the wasp or bee larva to starve to death. The insects are very easily recognized, the abdomen being made up of apparently a very few segments and the remainder modified into a telescopic and retractile tube, which is drawn within the body when not required. The species, though of moderate size, are among the most beautiful of our *Hymenoptera*, being adorned with brilliantly-metallic blue, green and ruby. The body is often deeply punctured, and the abdomen is frequently terminated by a series of more or less well-marked teeth. The insects are of no economic importance and we need not further consider them.

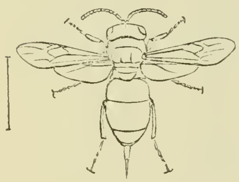


Fig. 180.
A cuckoo-bee, *Chrysis hilaris*. (After Packard.)

We now reach the ants, of which there are a number of families, but which for our purpose may be considered together, although they differ considerably in their habits, and in many cases even more in their life history. I need scarcely attempt to describe the ants, for every farmer has seen them of all sizes and of all colors, not only in fields, but frequently in houses, while they are common in woods, and especially in logs and stumps in a certain stage of decay. Some of the species in our State make quite considerable mounds. They are sometimes nearly three feet in diameter, although they rarely exceed from six to eight inches in height. There is a great deal of misinformation concerning these insects and their habits, and they are often looked upon by farmers as injurious; although, on the other hand, many seem to consider them as beneficial, claiming that they always see them where they see plant lice, and concluding, therefore, that they feed upon the lice. As a matter of fact neither conclusion is justified. The life history of the ants is a curious one, and they have an extremely complex social organization in many cases. In a

general way an ant-hill contains, first, the mother or true female, whose sole business it is, as in the case of the queen bee, to lay the eggs by which the population of the colony is kept up, and this mother ant is generally of a very much larger size than the other inhabitants of the nest. We may have one or several males living in the nest as partners to the queen, but the bulk of the population is made up of workers, or neuters, as they are generally called. As a matter of fact, the workers, as is the case among the bees, are really undeveloped females, in which the growth of the ovaries and other organs of reproduction has been checked. These do all the work of the colony, and look after the eggs and young larvæ that are hatched from them. The larvæ are stout, fleshy grubs, without traceable legs, and are absolutely incapable of helping themselves. They must be carried from place to place as may be necessary, and they must be fed day by day, and are absolutely dependent upon their nurses, the workers. The queen concerns herself only in laying eggs. When these larvæ are full grown they spin little, oval, silken cocoons, which the ants very frequently transport to the outside of the nest to get the benefit of the warmth of the sun, and if an ant-heap is disturbed, one will frequently see the ants running about, anxious first to secure these cocoons and carry them down underground into their galleries. Very often these cocoons are looked upon as the eggs of the ants. From them in due time hatch the adults, which may be workers, or males, or females. If they are workers they are not provided with wings; but both males and females are so provided. The males and females do no work; but remain in the nest until spring, when on some bright, warm day all of them will agree to leave the nest, and a swarming takes place. Thousands upon thousands of these flying ants, or "pismires," as they are frequently termed, will be seen at one time, and this is their marriage flight. After the females are impregnated they alight on the ground and seek a place to build a nest. As wings are useless to them under the new conditions they strip them off, and they never grow again. The food of ants is decidedly various, and in some cases consists of vegetable matter, largely the seeds of grasses and grain which the insects gather and store. Sometimes, as in the case of the harvesting ants in the southern and southwestern parts of our territory, they may become decidedly injurious; but we do not have in our State any ants that infest cultivated crops in such a way

that they can be considered as troublesome. Most of the species will feed upon animal matter, and undoubtedly many small insects are captured and destroyed, while any dead or dying specimen is seized almost immediately and carted off. In so far as they are predaceous they may be considered as beneficial, although they make no sort of distinction as to the character of the insects upon which they feed, and they will attack any beneficial insect just as readily as they will another. They are hardly of any advantage to the farmer from his standpoint. The relation of ants to plant lice is interesting, and is of

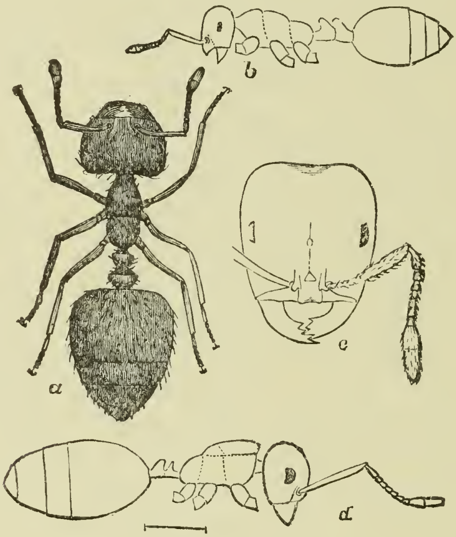


Fig. 181.

Solenopsis xyloni: *a*, worker-ant; *b*, same from side; *c*, its head; *d*, queen, from side. (After McCook.)

considerable importance. Plant lice, as is well known, excrete a sweetish liquid which is known as honey-dew, and of this liquid the ants are exceedingly fond. It is quite true that ants are usually abundant wherever plant lice are found, but they by no means injure the plant lice, but rather protect them, and the only business of the ants among the plant lice is to obtain the honey-dew, which the lice yield up to them readily when they are stroked by the antennæ or feelers of the ants. Some species are not satisfied with obtaining their supply of honey-dew in a haphazard way, but actually cultivate plant lice, usually of the varieties that feed on the roots of plants. On

turning over large stones at the foot of trees we quite often find that all the roots that run under the stones have had galleries excavated around them by the ants, and on these cleared roots thousands of the aphids feed, crowded together as closely as it is possible for them to be packed. Very often ants gather and store in their galleries the eggs of certain species of plant lice, keep them safe during the winter, and in the spring colonize them on the roots of such plants as they can feed upon. Eggs, which the entomologist has never succeeded in finding, are gathered by the thousands, and it is probable that some species of plant lice depend entirely upon ants to enable them to live during the winter. In one instance at least this may assume an economic importance, and that is in the case of the corn-root plant louse, which is tended by a species of ant and depends largely, if not entirely, upon it. In this view ants can be considered as distinctly injurious, although indirectly so, because, while they do not themselves injure the crop, yet they look after and preserve the plant lice, which are sometimes exceedingly destructive. It is a very grave question whether the insects that they destroy will overbalance the harm that is done by their nursing others. Ants, therefore, can scarcely be classed as beneficial insects, although in our State they are not injurious in the sense that would require active measures for their destruction.

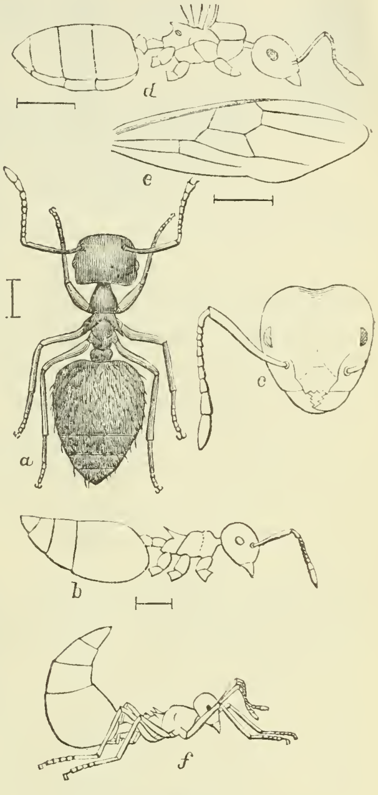


Fig. 182.

Cremastogaster lineolata: a, b, large worker; c, its head; d, female; e, its wing; f, small worker. (After McCook.)

Following the ants, we have the great series of wasps, of which there are several families, but which for our purpose need not be

specially distinguished. As was the case with the ants, wasps differ very greatly in habits. Some of them are solitary, that is, a male and female form a pair, which build a nest and produce young, which are also male and female only. Others are social—that is to say, besides the male and female, there are also workers produced, as is the case with the bees. We have a very large series that are fossorial or digging wasps, living largely in the ground, in which they excavate burrows and form cells stored with food for their larvæ. Others make channels in wood, and sometimes in living plants. The legs are formed for digging, and are not fitted for collecting pollen. Most of them are provided with stings in the female, and this sting is really a modified ovipositor.

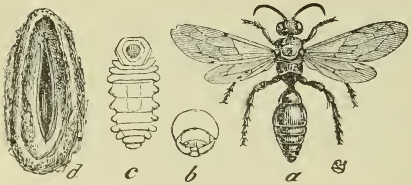


Fig 183.

White-grub parasite, *Tiphia inornata*: *a*, imago; *b*, head of larva; *c*, larva; *d*, cocoon. (After Riley.)

One series of these digging wasps, the *Mutillidæ*, is believed to be parasitic, or at least carnivorous, laying its eggs in the nests of bees, principally bumble-bees, and the larvæ feeding upon the larvæ of the bees. These *Mutillidæ* are frequently wingless, and resemble large ants, for which they are sometimes mistaken, but from which they differ by being furnished with an exceedingly vicious sting. They are often yellow or red in color, with black bands, and are seen running on sandy spots very much more rapidly than any true ant ever runs.

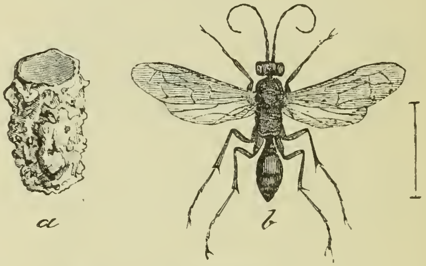


Fig. 184.

Agenia bombycina and its cell, which is to be filled with spiders. (After Riley.)

In the family *Scoliidæ* we have some that are said to be parasitic, and one species, *Tiphia inornata*, a black form, feeds upon the white grub or larva of the May-beetle.

The family *Pompilidæ* contains species that generally burrow in

sandbanks, provisioning their cells mostly with spiders, which they first paralyze. Some species, the legs of which are not fitted for burrowing, construct mud cells, placed irregularly side by side, upon walls.

Fig. 185.

Pepsis formosus: tarantula-killer. (After Riley.)

Others, belonging to the genus *Pepsis*, which are among the largest of our *Hymenoptera*, prey upon the tarantula. The habits of these

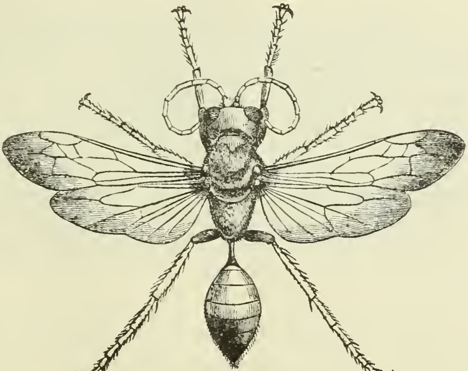


Fig. 186.

Sphex ichnumonea.

insects are extremely interesting, and particularly this habit of storing their nests with living spiders upon which the larvæ of these insects feed. The spiders are not killed but are carefully stung in such a way that they lose the power of motion and retain just life enough to prevent them from decaying. The young larva when it hatches finds itself in the midst of a supply of spiders, any one of which could destroy it with ease were it in possession of its faculties, but as it is it bores into the body of first one and then the other, feeding upon them until, when the entire supply of food is exhausted, the wasp larva has obtained its full growth and is ready to change to a pupa. Some others, belonging more generally to the family *Sphegidæ*, provision their nests with caterpillars as well as spiders, and many of this family build mud nests not only on walls but under the eaves of houses, and sometimes on shrubs and trees, occasionally of quite regular and pretty form. If we open some of these mud nests at the proper season of the year we will find them stored just as closely as it is possible to pack them with spiders or caterpillars, and no cell contains more than one kind of food. It is either all caterpillars or all spiders, and it is quite remarkable how nearly of a size the stored insects are. The number of caterpillars collected and destroyed by these mud wasps is enormous, and the insects rank, therefore, as among the most decidedly beneficial. In the family *Bembecidæ* we have some of our largest

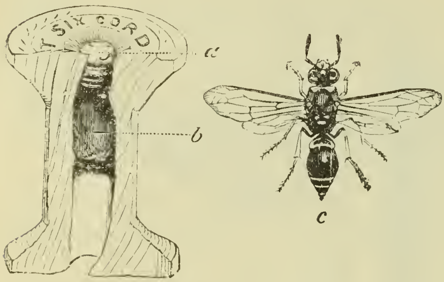


Fig. 187.

Odynerus flavipes and its mud nest, built in a spool; the nest stored with caterpillars. (After Riley)

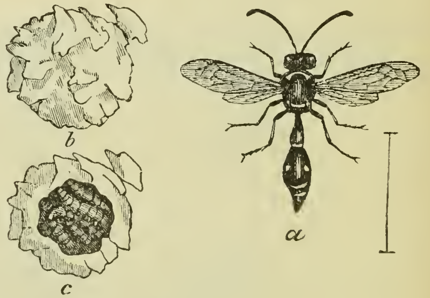


Fig. 188.

Fraternal potter-wasp, *Eumenes fraterna*: *a*, wasp; *b*, its cell; *c*, same broken open to show the caterpillars stored in it. (After Riley.)

species, one of them which occurs in this State being nearly two inches in length, and this has the interesting habit of feeding upon cicadas or harvest-flies, stinging them and carting them to its burrow as food for its larvæ. The species is more common southwardly, but occurs some years in considerable abundance from the middle of the State southward. It is rarely found north of Newark. In the family *Philanthidæ* we have species which are partial to different species of weevils, destroying a great number of their larvæ as food for themselves and their young, and of course these are also decidedly beneficial.

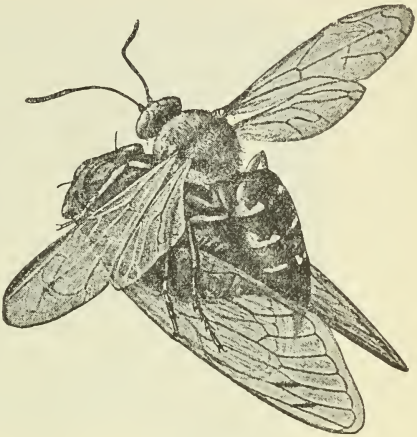


Fig. 189.

Female Sphecius carrying a cicada to her burrow. (After "Insect Life.")

In the family *Vespidæ* we have the social wasps, commonly known as the "hornets" and "yellow-jackets." They are all paper-makers, not out of rags, but out of wood; alighting upon some wooden surface exposed to the weather, they gnaw off with their strong jaws the

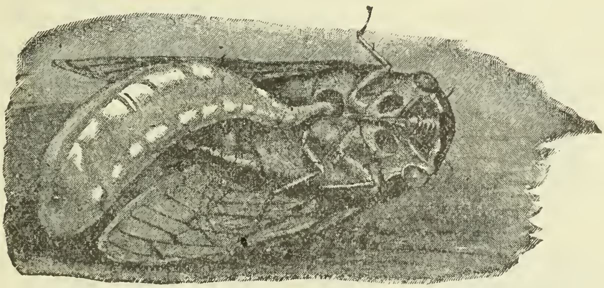


Fig. 190.

Larva of Sphecius feeding on cicada in burrow. (After "Insect Life.")

minute filaments of wood which have become partly detached by the action of the elements and chew them up into a fine pulp, which they afterwards spread out into thin sheets of strong, gray, water-

proof paper, that forms the material of their nests which are found generally suspended from the branches of trees, and sometimes in the corners of outbuildings. Some species, for instance the yellow-jackets, previously noticed, build their nests underground, much on

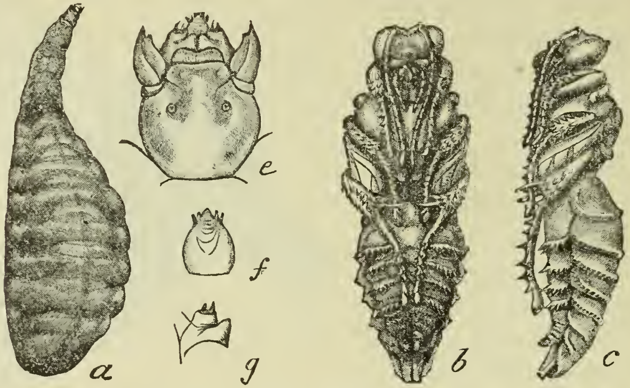


Fig. 191.

a, larva of Sphecius; *b*, *c*, pupa; *e*, *f*, *g*, details of larva. (After "Insect Life.")

the same principle as those built above ground. The species of *Polistes*, which have a more slender body, build combs or a series of paper cells in various sheltered places, principally on the roof timbers of barns and other outbuildings; but always without an envelope or covering as is used in the case of the species of *Vespa*. In these social wasps we find workers represented as well as males and females, and many of them prey upon other insects.

Fig. 192.

White-faced wasp, *Vespa maculata*. (After Riley.)

As a whole, we may say that the wasps are decidedly beneficial insects. There are none that can be considered as injurious, while it has been shown that a great many of them subsist entirely upon insects that are injurious to the farmer. To be sure their habit of feeding upon spiders is not one that is especially to be commended, for spiders are themselves useful, and also destroy a great number of injurious insects; but the balance is largely in favor of the benefits to be derived, and hence wasps should not be wantonly disturbed.

Highest in the series of the *Hymenoptera* are the bees, solitary and social, and these are of very great interest from their habits and their social organization. All bees, in their larval as well as adult stages,

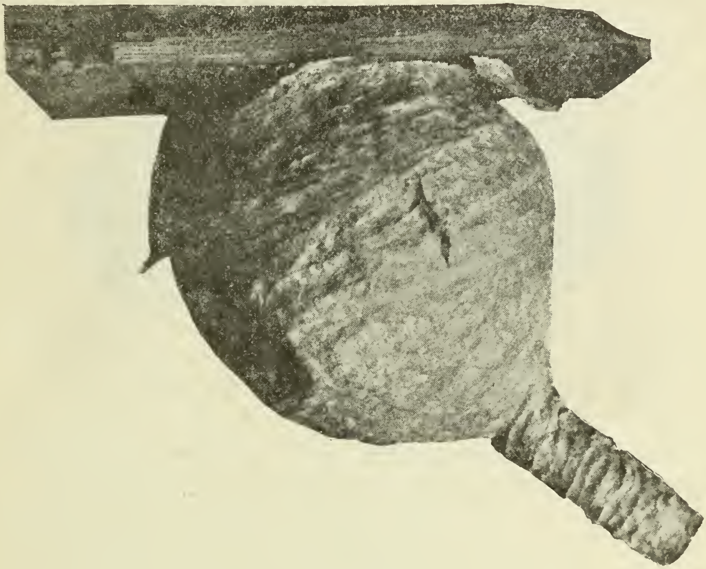


Fig. 193.

Nest of *Vespa maculata*, just started. (From a photograph)

are feeders upon honey and pollen, and they make their cells and nests in a great variety of ways. Some of them, like the digging wasps, make their cells underground. Others, like the carpenter-bees, bore immense holes in dead wood; others live in the hollow

Fig. 194.

Polistes americana. (From U. S. Dept. Agri.)

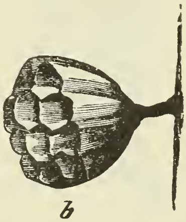


Fig. 195.

Nest of *Polistes*, just started. (After Riley.)

stems of various plants, while others again excavate the pith in plants, like the elder, for instance. Some of them make their cells of fragments of leaves which they cut from the plant. It is quite usual to

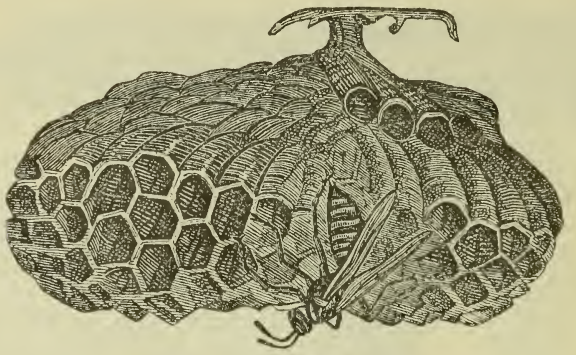


Fig. 196.

Nest of *Polistes gallicola.* (After Figuier.)

see on rose bushes leaves which have a semicircular piece cut out from the edge, and this is the work of these leaf-cutting bees. In so far as they thus disfigure certain plants, they may perhaps be considered somewhat injurious, but no real damage is ever done, and the bees generally make up what little trouble they cause in this way by their usefulness in fertilizing the flowers of very many species of plants. No agency among insects compares with bees in this important function, and an abundance of bees in an orchard generally means a good setting of fruit, while on the other hand an absence of bees, or a spell of weather which prevents their flight, will result in the absence of a set. Some clovers are almost entirely dependent upon bees for fertilization, and until bumble-bees were introduced into Australia no red clover seed could be obtained. Bees are therefore beneficial, not in the sense in which carnivorous, predaceous or parasitic insects are beneficial, but in

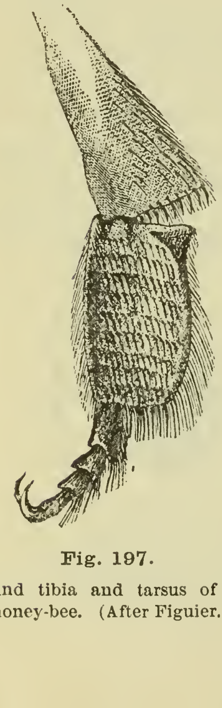


Fig. 197.

Hind tibia and tarsus of a honey-bee. (After Figuier.)

really a much higher and more important sense, because they influence the set of the fruit in the first place, and wherever horticulture forms a leading industry apiculture should also be carried on. The most important habit which makes bees so useful in fertilizing plants is that of gathering pollen. Pollen is needed as food for the bee larvæ, and the bees fly from flower to flower, robbing each of this substance, but incidentally also pollenizing almost every flower visited. A habit of theirs to visit only flowers of one kind in each flight additionally favors this result. The pollen is gathered in little round balls or lumps, which are carried in the "pollen baskets," situated on the posterior legs, and none but true bees are furnished with these structures; even in them the males are without the baskets, since they do not work. The direct benefit to be derived from cultivating bees for honey does not enter into the scope of the present paper.

We have thus covered in a very general way, and of course far from completely, all the orders of insects, with the special view of pointing out those that are beneficial, and including a brief description of how they may be recognized. It is manifestly impossible to go into much detail in a report of this character, but it is at least important for the farmer to know that insects as a whole are not to be universally condemned, for there are many more which are active in his behalf than there are seeking the destruction of his crops; and I have tried to show that nature makes efforts to prevent too much injury to plant life from those species which feed upon it. I have tried to show, too, that it is man's interference with nature's methods which induces and favors the undue multiplication of those forms that feed upon cultivated crops, and I have tried to teach that as man has disturbed nature's balance by his own acts, he must either bear the penalty or he must himself take active measures for his own protection. We cannot rely upon nature to repair disturbances that we ourselves have caused. We must, by active measures, ourselves seek to remedy them, and while all series of parasites and predaceous forms are active in the farmer's behalf, yet they will never suffice for his protection without his individual effort. It is necessary, further, that crops be grown in such a way as to prevent the development of the injurious species, or they must be protected by means of poisons or otherwise.